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Chest CT scan patterns of COVID-19 Pneumonia at Girum Hospital, Addis Ababa, Ethiopia.

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Abstract

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Background: Coronavirus Disease 2019 (COVID-19) is a rapidly spreading infection which was declared as a pandemic by the World Health Organization, in March 2020. The standard for diagnosis of COVID-19 is reverse transcription polymerase chain reaction (RT-PCR) test. According to our literature search, in our country there is a considerable knowledge gap regarding the Chest CT imaging features of COVID- 19 and factors associated with it, to date, as the disease is a new occurrence in time and is yet to play out.

Objectives: The main aim of this study is to evaluate the Chest CT scan features of COVID-19 at Girum Hospital, Addis Ababa, Ethiopia, from June 2020 to February 2021.

Methods: This cross-sectional study used secondary data of all patients with confirmed COVID-19 (RT- PCR Positive) who had Chest CT imaging in Girum Hospital from June 2020 to February 2021. Data collection template was used to collect data elements from the respective Chest CT images and Electronic Medical Records of patients. Data was entered in to EPI Info version 7, transferred to SPSS version 26, and descriptive methods were used to determine patterns of findings and analytic methods were used to find associations between variables.

Results: A total of 162 patients with COVID-19 pneumonia were evaluated. The commonest duration in days between symptom onset and Chest CT imaging was 5-8 days in 77(47.5%) patients. One or more Comorbid illnesses were present in 68(42.0%) patients. The most common Chest CT imaging finding seen in 106 (65.4%) patients was a widespread ground-glass opacity being bilateral and peripheral, and especially involving the lower lobes.

Conclusion: The observed features of COVID-19 on chest CT imaging show similarities to other viral infections' chest CT patterns. Unknown aspects need to be further researched.

Keywords: COVID-19, CT findings, Ethiopia and Radiologic Studies.

Background

In December 2019, a highly infectious disease emerged in the city of Wuhan in Hubei province, China, which was later proven to have been caused by a novel coronavirus, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) [1]. Ethiopia is one of the countries that registered COVID-19 cases since 13th of March 2020, two days later after the WHO declared a pandemic of the disease [2]. Chest x-ray and CT scan are the most commonly used for diagnosis and management of COVID-19 patients, with chest CT scan being more accurate and sensitive in identifying COVID-19 at early stages [3].

The need of a uniform and standardized reporting scheme and language, in chest CT imaging of COVID-19 pneumonia, has been welcomed by major scientific societies. Therefore, structured report based on chest CT patterns of COVID-19 has major contribution to compare data across institutions and populations and, thus, provide a basis for gathering scientific evidence and improved communication with referring physician who are faced with the management of patients. There are not many studies done in Ethiopia on chest CT patterns of COVID-19. In addition to this, with the limited diagnostic resources effective and exploitive use of resources at hand and documentation of these radiological patterns is deemed necessary. This study will help define the role of imaging and provide as a base line for future large-scale radiologic researches in our country as its first of its kind.

Methods and materials

Study setting, design, period, and population

The study was conducted at Girum Hospital located at Gulele, Addis Ababa, Ethiopia. The Hospital had an isolation center for suspected COVID patients since the beginning of the pandemic and established a COVID treatment center in September 2020.The study was conducted from February 2021 to August 2021.The study design is an institution based cross sectional quantitative Study.

Data collection and tools

A total of Hundred sixty two patients who attended Girum Hospital from June 2020 to February 2021 with a confirmed COVID-19 (RT- PCR Positive, age >18 years,) and who had Chest CT imaging with complete clinical data on radiology information system (RIS) were enrolled in this study.

A data collecting template was adopted and modified from the Radiological Society of North America Expert Consensus Document on the Reporting of Chest CT Findings Related to COVID-19.

Study variables and operational definitions

Typical appearance, indeterminate appearance and atypical appearance were the dependent variables, while the independent variables were patients: age, sex, Comorbid Illness and Duration between symptom onset and Chest CT Imaging.

The operational definition for the Patterns of Chest CT imaging findings is originally derived from the Radiological Society of North America Expert Consensus Document on Reporting Chest CT Findings Related to COVID-19 [4] and adjusted according to above reviewed literatures. (Table 1.)

Table 1: Proposed Reporting Language for CT Findings Related to COVID-19. [4]

Imaging classification	CT images
Typical appearance	✓ Ground-glass opacities ✓ Consolidation ✓ Mixed ground-glass opacities and consolidation ✓ Reverse halo sign
Indeterminate appearance	✓ Interlobular septal thickening ✓ Crazy-paving pattern ✓ Adjacent pleura thickening ✓ Air-bronchograms
Atypical appearance	✓ Discrete small nodules (centrilobular, “tree-in-bud” appearance); ✓ Lung cavitation; ✓ Pleural effusion ✓ Lymphadenopathy
Negative for pneumonia	✓ No CT features to suggest pneumonia

The operational definition for the Duration between the onset of symptoms and Chest CT imaging is classified; as 0-4, 5-8, 9-13 and ≥ 14 days according to a retrospective study published in June 2020, which involved 21 patients form China and was done to determine the changes in chest CT findings associated with COVID-19 from initial diagnosis until patient recovery.

Data Processing and Analysis

After data collection, it was checked for completeness and entered into SPSS Version 26. Descriptive statistics was used to explore the data in relation to relevant variables. Furthermore, logistic regression was done to determine the association between the dependent and independent variables. First, Bivariate analysis was done and those variables with a p value of <0.05 were entered in the multivariable logistic regression model. All statistical analysis was set at 5% level of significance (i.e. $p < 0.05$). The results were reported using Odds Ratio and 95% CI. Continuous variables were expressed as mean, standard deviation and appropriate tables and graphs were used to present findings.

Results

Socio-demographic characteristics of participants

Of the total 162 COVID-19 patients included in the study 60(37%) and 102 (63%) were female and male respectively. The mean ± SD age of the study participants was 52.05±16.25 years, ranging from 18–89 years. The majority of the participants in this study fall in the age group ≥56, 73(45.1%).

Clinical characteristics of study participants

77(47.5%) patients had CT imaging done in the 5-8 days range after their onset of symptoms accounting for the majority. One or more comorbid illnesses were present in 68(42.0%) patients, of which 36(52.9%) had DM, which was the commonest comorbid illnesses.

Chest CT Features of COVID-19 Patients

Among the 162 patients in the overall sample, the Chest CT findings showed Typical imaging findings in 157(96.9%) cases, Indeterminate imaging findings in 134(82.7%) cases, Atypical imaging findings in 20(12.3%) cases, whereas the Chest CT appearance was negative for pneumonia in 4 (2.5%) cases. (Table 2) Ground-glass opacities were the most prevalent Typical CT feature seen in 106(65.4%) cases. (Figure 1).

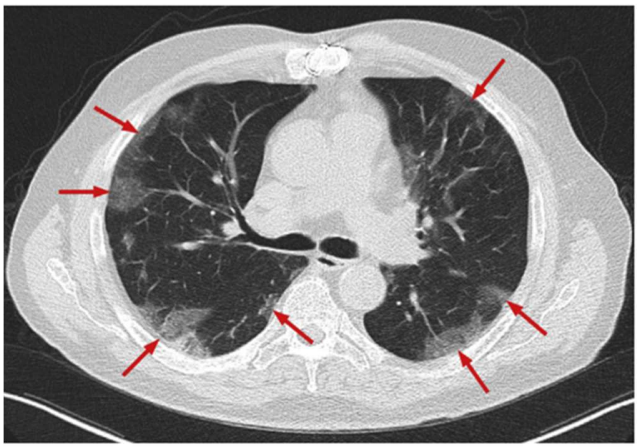

Figure 1: Axial chest CT image shows bilateral, multifocal ground-glass opacities that were predominantly located peripherally

In regards to the Duration between symptom onset and Chest CT imaging findings, in CT scans obtained in the first 4 days the predominant imaging finding was ground-glass opacities (91.1%). In the scans obtained between 5–8 days and 9–13 days, a mixed ground-glass and consolidative opacity was the predominant imaging finding accounting for 68.8% and 76 % respectively. Scans obtained ≥ 14 days showed consolidation (66.7%) as the predominant CT finding.

Table 2: Chest CT imaging features of patients with RT-PCR confirmed COVID-19 infection at Girum Hospital from June 2020 to February 2021, Addis Ababa, Ethiopia

Imaging Classification	CT Features	Patients No (%)
Typical appearance	Ground-glass opacities	106(65.4)
	Consolidation	54(33.3)
	Mixed ground-glass opacities	93(57.4)
	Reverse halo sign	73(45.1)
Indeterminate appearance	Interlobular septal thickening	75(46.3)
	Crazy-paving pattern	43(26.5)
	Adjacent pleura thickening	66(40.7)
	Air-bronchograms	72 (44.4)
Atypical appearance	Discrete small nodules (“tree-in-bud” appearance)	8(4.9)
	Lung cavitation	5 (3.1)
	pleural effusion	8 (4.9)
	Lymphadenopathy	5(3.1)
Negative for pneumonia	No CT features to suggest pneumonia.	4(2.5)

Anatomic Distribution of lesions in the Lungs of patients with COVID-19

In terms of lesion distribution, distribution was predominantly peripheral in 132(81.5%) cases, central in 61 (37.7%) cases, bilateral in 123 (75.9%) cases and unilateral in 39(24.1%) cases. The lobar involvement in our study in descending order was, right lower lobe in 142 (87.7%) cases, left lower lobe in 134 (82.7%) cases, with equal right upper lobe and left upper lobe involvement in 110(67.9%) cases and right middle lobe in 87(53.7) cases. Out of the different age groups found in this study, the highest number of cases with extensive lobular involvement with all 5 lobes being involved was noted in the ≥56 years patient age group, with 34 cases identified, among the total of 70 cases with 5 lobe involvement.

Regression Analysis between of the Dependent and Independent Variables

To identify factors associated with CT imaging, logistic regression was done among the Outcome variables and the independent variables separately. However, there was no statistically significant association between the Dependent and Independent Variables.

Discussion

In this study, among the Typical Chest CT imaging appearances, ground glass opacity was the most prevalent feature. This result is also seen in a systematic review and a meta-analysis study conducted in China, which identified ground glass opacity as the most common imaging finding with occurrence rate of up to 95% [4,5]. Similarly, a retrospective cross-sectional study done on chest CT findings of COVID 19 patients in Jordan, among the several patterns of the pulmonary changes, the ground-glass pattern was present in 96.7% cases [6]. Compared to a descriptive study done in Mogadishu, Somalia, on the clinical and chest CT presentations of 27 patients with COVID-19 pneumonia, the most common patterns of abnormality seen on chest CT was ground-glass opacity (GGO),seen in 74.1% of the cases [7]. The very high prevalence of the ground glass opacity in these studies is likely explained by the short Duration between symptom onset and Chest CT imaging in the majority of their participants.

Following the commonest CT findings, the ground glass opacity, which is categorized as a typical finding, Interlobular septal thickening 75(46.3%), Crazy-paving pattern 43(26.5%), Adjacent pleura thickening 66(40.7%) and Air-bronchograms 72 (44.4%) were categorized as Indeterminate appearance. Likewise, discrete small nodules ("tree-in-bud" appearance) 8(4.9%), Lung cavitation 5 (3.1%), pleural effusion 8 (4.9%) and Lymphadenopathy 5(3.1%) were categorized as Atypical CT findings. Similar to this, according to a Meta-analysis of CT imaging features of 4121 patients with COVID-19 in China on April 2020 found Interlobular septal thickening (39.5%), crazy-paving pattern (35.6%), pleura thickening (36.8%) and air bronchogram (44.7%) as the indeterminate imaging findings. Likewise nodular pattern (20.5%), Lymphadenopathy (5.4%) and pleural effusion (5.3%) were among the atypical findings [8]. While vast majority of cases present with typical imaging findings the presence of indeterminate and atypical findings can be attributed to superimposed infections or concurrent comorbidities.

As demonstrated by the findings in this study, with regards to the Duration between symptom onset and chest CT imaging findings, Ground-glass opacity was the commonest finding (91.1%) in the early stage (0-4days) of the disease. In coherence with this, a systematic review of chest CT findings in 4410 adult patients in china, in the early follow-up period, CT imaging generally showed GGOs, with progression into mixed areas of GGOs plus consolidations peaking at the 10th and the 11th days [1]. Similarly, this study demonstrated mixed ground-glass opacity and consolidation as the predominant finding accounting for 68.8% and 76 % between 5–8 days and 9–13 days respectively. Scans obtained ≥ 14 days showed consolidation (66.7%) as the predominant CT finding. Correspondingly, according to the Radiological Society of North America Expert Consensus Document on March 2020 on the Reporting of Chest CT Findings Related to COVID-19, the frequency of consolidation increases in the late course of the disease [9].The changes in the Typical imaging appearances, with regard to the duration between symptom onset and chest CT imaging, might indicate the progression of the illness.

In terms of lesion distribution, in this study the predominant distribution was peripheral in 132(81.5%) cases and bilateral in 123 (75.9%) cases. Likewise, this result is consistent with, a meta-analysis study conducted in China, which showed Imaging findings mostly involved the bilateral lungs and were located in the peripheral area of the lungs. However, the infection can involve all the lobes and mostly an extensive

involvement is common and predominately bilateral lower lobes are commonly involved. Similarly, the findings of this study evidenced all the lobes of the lung can be involved, particularly 5 lobes were involved in 70(43.2 %) of cases, with predominance at the lower lobes, the right lower lobe being involved in 142 (87.7%) of cases, and the left lower lobe being involved in 134 (82.7%) of cases. [2,10].

In this study one or more Comorbid illness was present among 68 patients among whom 60 of them had a multi-lobar involvement with either 4 or 5 lobes being involved. And the patient age group with the highest number of lobar involvements was the ≥56 age group accounting for the 34 cases amongst the 70 cases with 5 lobe involvement. Like-wise according to a retrospective study published in October 2020 for assessing the effect of comorbidity on patients with COVID-19 on 294 patients from China, extensive lung volume involvements were found in patients with any comorbidity than without comorbidity. The more comorbidity patients had the more lesions CT images showed [11]. And similarly, an extensive multi-lobar involvement was more predominant in patients who were older than 50 years than in those who were 50 years or younger [12].

Limitations of the study

The limitation of this study is, since it's an institutional based cross-sectional study, it was merely a situational analysis of the Chest CT findings.

Despite the limitation of this study, since Chest CT imaging features of COVID-19 are still unfulfilled, unknown aspects need to be further researched using different research modalities like systemic reviews, metanalysis and qualitative studies. Clinicians and radiologists need to be familiar and have high index of suspicion for various manifestation of COVID-19 on Chest CT images to suggest it as a possible diagnosis. Proper documentation of clinical and imaging findings is crucial to understand the patterns and progress of the disease.

Conclusion

In conclusion, the most common feature of COVID-19 on Chest CT images is ground-glass opacity, with a bilateral, peripheral distribution and with a widespread involvement of all lobes, particularly with predominance in the lower lobes. In addition, the typical imaging manifestations differed according to duration of imaging from symptom onset which might indicate the progression of the illness. Patients with comorbidities and older age tend to show an extensive multi-lobar involvement.

Abbreviations

CT: Computed Tomography

COVID-19: Coronavirus Disease 2019

GGO: Ground Glass Opacity

RIS: Radiology Information System

RSNA: Radiology Society of North America

RT-PCR: Reverse Transcription Polymerase Chain Reaction

SARS-CoV 2: Severe Acute Respiratory Syndrome Coronavirus 2

SPHMMC: St. Paul's Hospital Millennium Medical College

WHO: World Health Organization

Declarations

Consent for publication

Participants consented for unanimous sharing of compiled data as approved by the IRB of the college at SPHMMC

Ethical declaration

The St. Paul Hospital Millennium Medical College- institutional review committee has given its approval for the ethical use of the data. All-study methods, and protocols, were carried out in accordance with SPHMMC, Ethiopian national and regional regulations and Guidelines. This is not experimental study and stating experiments on humans and/or the use of human tissue samples is not applicable to this study. Since we used secondary data having consent of participant was not applicable to our study

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Competing Interest

All authors read and approved the final manuscript. We have no conflict of interest.

Availability of Data and Materials

The datasets used in the current study or data collection tool are available from the corresponding author with a reasonable request.

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