Evaluation of chest computed tomography alterations of patients hospitalized by Covid-19

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ABSTRACT

Introduction: SARS-CoV-2 has rapid dissemination and high infectivity and can evolve into Severe Respiratory Distress Syndrome (SARS), which led to a high number of deaths and hospitalizations in the recent pandemic. Computed tomography (CT) of the chest has demonstrated an essential role in the initial evaluation and evolution of these patients. **Methodology:** This was a retrospective observational study at a single center, University Hospital in Northeastern Brazil, evaluating 97 patients hospitalized for COVID-19 with laboratory confirmation to evaluate and quantify the chest CT findings, comparing the findings with the severity of the case and relating them to the morbidities presented. The CT scans were performed by radiologists from the hospital and the data were evaluated by the university's statistics laboratory. **Results:** Among the main alterations, ground-glass opacities were present in more than 90% of the patients. The study observed that the magnitude of the pulmonary involvement of this finding had a relationship with the outcome of higher hospitalization. **Conclusion:** In this sense, the relevance of chest CT to suggest the diagnosis of Covid-19 and establish the prognosis of the disease is observed. However, further studies are still needed to confirm these findings.

Keywords: COVID-19, Computed tomography, Pneumonia, SARS-CoV-2.

INTRODUCTION

The SARS-CoV-2 pandemic had its first record in December 2019, with rapid spread across all continents afterward. The disease has high infectivity and can evolve with Severe Respiratory Distress Syndrome (SARS), leading to a high number of deaths and hospitalizations[1]. Furthermore, this pandemic affected health, social, economic, and educational spheres, highlighting its relevance for the present. The clinical manifestations of SARS-CoV-2 pneumonia involve fever, fatigue, dyspnea, and dry cough, in addition to presenting a very frequent clinical sign of hypoxemia. As the disease is systemic, with the involvement of the endothelium, there may be other clinical presentations, such as diarrhea, headache, myalgia, anorexia, and anosmia[2].

SARS-CoV-2 is a virus transmitted by infected respiratory droplets, which invade the airways and vascular bed and can cause a severe immune/inflammatory response, which affects several organs: lungs, heart, kidneys, and gastrointestinal tract, which justifies the diversity of clinical presentations[3].

In this context, chest Computed Tomography (CT) has demonstrated an essential role in helping the diagnosis of COVID-19, evaluating complications, and the prognosis of patients through various imaging findings. According to these imaging findings, the ground-glass pattern, predominantly peripheral and bilateral in distribution, showed greater sensitivity as a CT finding; however, it is not specific to COVID-19[2]. In addition, other imaging findings can be observed, such as consolidations, air bronchogram, septal thickening associated with ground glass, and pleural thickening. Some of these tomographic alterations constitute known radiological signs, such as mosaic paving and the halo sign[4]. Also, it should be considered that there is an evolution in the CT abnormalities found in these patients over the days of symptoms, which there is already a record in the literature of the relationship between the worst manifestations of CT and the patient's prognosis, and one can use CT scores to assess the probability of diagnosis and case evolution[5].

Furthermore, intrinsic clinical factors of the patients also affect the prognosis of the infection. For example, elderly patients with immunodeficiencies, diabetes, cardiovascular disease, and chronic

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lung diseases have a worse outcome when infected with SARS-CoV-2, in addition to tending to show more changes in chest CT. However, this relationship is not well understood in general, but specifically in some cases.[6]

Therefore, this study aimed to analyze possible correlations between these clinical variables and tomographic findings, describing the results found in this center in the interior of Northeast Brazil.

MATERIAL AND METHODS

It was a cross-sectional observational retrospective study carried out with patients at the Hospital Universitário Alcides Carneiro, which received approval from the ethics committee of the referred institution (number: 4,974,312). Data from the medical records of the evaluated patients, who underwent the Computed Tomography (CT) chest scan during hospitalization between May 2020 and December 2021 were used. The informed consent form was waived, as this was a retrospective study. The CT scan was performed by a professional radiologist from the same hospital.

Identification data from the imaging exam were collected; sex; age; an examination to confirm the diagnosis; previous morbidities; the time between admission and performance of chest CT; oxygen support; vaccination for Covid-19; ground-glass involvement in lungs; other chest CT findings reported, related or not to SARS CoV-2; evolution of hospitalization and outcome.

Data were collected through an individual online form, being evaluated through the Statistical Analysis Laboratory of the Federal University of Campina Grande.

Patients and controls

In the service where the analysis was carried out, patients were referred after the suspicion or confirmation of Covid-19 requiring hospitalization.

Inclusion criteria

Patients aged 18 years and older who had a confirmed diagnosis of COVID-19 (serology, if they were diagnosed with COVID-19 before vaccination; rapid test with a nasal swab for antigen evaluation and nasal/oropharyngeal swab with PCR evaluation) were selected, with criteria for hospitalization in the service.

Exclusion criteria

Patients in the pediatric age group and patients without a chest CT report available were excluded.

Classification of CT findings

The magnitude of the involvement of the findings in the CT scans was obtained by intervals in percentage from the visual evaluation of the radiologist, who described the finding in the tomographic report, using standard protocols of the academic societies and from the service.

Statistical analysis

Initially, a descriptive analysis of the data was performed using graphs and frequency tables for qualitative variables. Furthermore, with the guidance from the descriptive analysis, possible associations between the outcome variable (death or discharge) and the variables septal thickening, pleural effusion, consolidation, sex, comorbidities, and the presence of ground-glass opacities were verified. To confirm this association, the chi-square test of independence, Fisher's exact test, and the Cochran-Armitage trend test were used.

RESULTS

Patients' personal information

A total of 97 patients participated in the study, most of them male (57 patients, 59% of the cases).

The mean ages of male and female patients are similar (55 years for females and 56 years for males). Fifty percent of male patients were younger than 52 years old, while 50% of female patients

were aged between 41.8 and 66.2 years. The age distribution of male patients has a greater range of ages (range between minimum and maximum age of 78 years), but the ages of female patients have a slightly higher dispersion when compared to the age distribution of patients in the male. Without stratifying by sex, the mean age of the patients is 55.6 (with a standard deviation of 17.5 years) years and 25% of the patients were older than 67 years.

Diagnosis

To confirm the diagnosis of Covid-19, different tests were used: RT-PCR, serological, and rapid antigen detection test. The technique less used was based on antigen detection, used in only 2.1% of the tests. The technique most used was RT-PCR in 48.5% of the tests. It is also important to highlight that for 14.4% of the patients, the technique for laboratory confirmation of the diagnosis was not informed. Patients who used serology for diagnosis had not been vaccinated at the time of the study.

Vaccination against COVID-19

During the patients' hospitalization, their vaccination status was verified. **Only 1% of the patients had the vaccination cycle with two doses of the vaccine or more during hospitalization.** Fifty-six percent of hospitalized patients did not have any vaccination dose.

Comorbidities

Of the 97 patients who took part in this study, 82% had some type of comorbidity.

Ground Glass Opacity

This type of pattern in the tomography exam is frequently observed in patients with respiratory infections caused by SARS-CoV-2, although it is not specific. Only 7.2% of patients hospitalized for Covid-19 did not have ground glass on their chest CT at admission.

Table 1

Distribution of patients based on comorbidities.

Classification	Quantity	Percentage
Uninformed	3	3%
Absent	14	14%
Presents	80	82%
Total	97	100%

Table 2

Distribution of comorbidities reported by patients.

Comorbidities	Quantity	Percentage
Immunodeficiency	2	2.1%
Current smoking	4	4.1%
Chronic kidney disease	7	7.2%
Former smoker	7	7.2%
Liver disease	8	8.2%
Heart disease	10	10.3%
Neurological disease	10	10.3%
COPD	14	14.4%
Others	19	19.6%
Obesity	23	23.7%
Diabetes mellitus	30	30.9%
Systemic arterial hypertension	48	49.5%
Total	182	-

Caption: COPD: Chronic obstructive pulmonary disease

Table 3

Distribution of patients concerning the presence of ground-glass opacity on computed tomography (CT).

Percentage (affected area)	Quantity	Percentage (results)
Absent	7	7.2%
(0%, 25%)	10	10.3%
(25%, 50%)	24	24.7%
(50%, 75%)	40	41.2%
(75%, 100%)	11	11.3%
Not quantified	5	5.2%
Total	97	100.0%

Other CT imaging findings

Table 4 presents different tomographic findings and the frequency they appeared in the exams, with the percentages in parentheses.

Oxygen support

In cases where some type of oxygen support was required, the following were used: nasal catheter, non-invasive mechanical ventilation (NIV), invasive mechanical ventilation (IMV), and non-rebreathing O2 reservoir mask (MR O2). In Table 5 it is possible to notice that 7.2% of the patients did not need oxygen support, whereas 58.7% used some type of mechanical ventilation, and 41.2% of the patients used IMV.

Hospitalization outcome

Of the 97 hospitalized patients, 74% received hospital discharge and 26.0% died.

Table 4

Frequency of tomographic findings.

Types of findings	Present	Absent
Septal thickening	65(67%)	32(33%)
Pulmonary fibrosis	3(3%)	94(97%)
Laminar atelectasis	17(17.5%)	80(82%)
Segmental/lobar atelectasis	16(16.5%)	81(83.5%)
Pleural effusion	27(27.8%)	70(72.2%)
Pneumothorax	0(0%)	97(100%)
Pulmonary consolidation	62(63.9%)	35(36%)
Bronchiectasis	1(1%)	96(99%)
Air trapping	1(1%)	96(99%)
Pulmonary hyperinflation	1(1%)	96(99%)
Pulmonary cysts	3(3%)	94(97%)
Pulmonary artery thrombus	0(0%)	97(100%)
Dilation of the pulmonary	4(4.1%)	93(96%)
artery Emphysema	5(5.1%)	92(94.8%)
Pulmonary mass	2(2%)	95(98%)
Pulmonary nodule	11(11.3%)	86(88.7%)

Table 5

Distribution of patients according to the type of oxygen support received during hospitalization.

Type of support	Quantity	Percentage
Absent	7	7.2%
NBR	16	16.5%
Nasal cannula	17	17.5%
NIV	17	17.5%
IMV	40	41.2%
Total	97	100.0%

Caption: NBR: Non-rebreather mask / NIV: Non-invasive mechanical ventilation / IMV: Invasive mechanical ventilation

Sex versus outcome

Of the female patients, 72.5% received hospital discharge, while for males, this result was 75.4%. Thus, this evidence that the gender variable does not appear to influence the patient's outcome.

Comorbidities versus outcome

Table 6 (Figure 6) shows the outcome of patients regarding the presence of comorbidities. Three patients who did not report the presence or absence of comorbidities were excluded from the analysis. Of the 94 patients in the study, all patients without comorbidity were discharged, while of patients who had some comorbidity, 28.7% of those died, showing that apparently there is a possible relationship between the outcome and the presence or absence of comorbidities.

The chi-square association test (χ 2) for the variable comorbidities concerning the outcome variable (death or discharge) was 0.049. Due to the presence of cases with an expected frequency of less than 5, Fisher's exact test was used to compare comorbidities versus outcomes. A p-value (0.02) was obtained, which shows an association between the variables at a 5% significance level. The result for the odds ratio for this variable was that the chance of a patient without comorbidities being discharged is approximately 12 (11.852) times the chance of a patient with comorbidities.

Ground Glass Opacity vs Outcome

For the analyses below, we disregard the "non-quantified" cases. This measure is necessary

Table 6

Patient outcomes concerning the presence of comorbidities.

	Outcomes		
Comorbidities	Hospital discharge	Hospital death	Total
Absent	14 (100.0%)	0 (0.0%)	14 (100.0%)
Presents	57 (71.2%)	23 (28.7%)	80 (100.0%)
Total	71 (75.5%)	23 (24.5%)	94 (100.0%)

to avoid possible confusion in the analyses. They were divided into four classes of 25% width; it was observed that as the opacity increased, the number of highlights decreased. Hence, it demonstrates that, apparently, the frosted glass variable influences the patient's outcome.

As the ground glass opacity variable has an ordinal character, the most appropriate test in this context is the Cochran-Armitage test. The result for the Cochran-Armitage test found evidence of an association between the ground-glass opacity variable and the outcome (p-value = 0.059) at a 10% significance level.

Given that there was statistical evidence of an association between the variables, we calculated the odds ratio of a patient who received hospital discharge without ground-glass opacity and a patient who had ground-glass opacities in the range of 75% to 100%. On other intervals, the result for the calculated odds ratio was very low, so we restricted ourselves to the interval of 75% to 100%. The chance that a patient without ground-glass opacity in the interval of (75% to 100%) received hospital discharge is approximately 2 (2.1) times the chance of a patient with ground-glass opacity in the range of (75% to 100%), with a confidence interval [0.277; 15.898].

DISCUSSION

The main findings of this study revolve around the interrelation between the Chest Computed Tomography findings of patients hospitalized for COVID-19, the severity of their cases, and the comorbidities presented by these patients admitted to a University Hospital in the state of Paraíba, Brazil.

It is important to emphasize the need to develop research like this at the regional level, aimed at understanding how COVID-19 specifically affects certain epidemiological profiles.

Most patients hospitalized for Covid-19 were male, which is also observed in other studies and systematic reviews, which may suggest a greater susceptibility of men to contracting Covid-19. This finding may result from extrinsic factors[4] such as a long time to seek health services or intrinsic factors to gender[5,7]. However, it was observed that there was no correlation of effect between the gender variable and mortality.

Concerning the observed imaging findings, the most frequent were septal thickening associated with ground glass, affecting 67% of patients, which is defined as "mosaic paving", an imaging finding initially considered specific for Pulmonary Alveolar Proteinosis but currently already observed in several pathologies, among them, Covid-19[2]. Another prevalent finding was the presence of consolidations (64% of patients) and pleural effusion (Table 4). These last findings may also occur in cases of bacterial infections acquired concomitantly with the viral infection, which, depending on the clinical and laboratory presentation, may justify the use of antibiotics.

The magnitude of pulmonary involvement and the association with other imaging findings (consolidation, septal thickening, and pleural effusion) and comorbidities were related to a worse prognosis for the patient, with a higher frequency of deaths in the groups with these alterations compared to patients who did not present. This can be explained by the fact that they denote greater severity to the patient's condition since these findings suggest impairment of lung expansion and ventilation, raising the hypothesis about the impact that respiratory physiotherapy could have on the evolution of hospitalization[2,8].

About these findings of ground glass, it was observed in 92.8% of patients hospitalized for COVID-19 at HUAC during the study period, evidencing its sensitivity to the pathology. This is relevant considering that laboratory tests may require more time to obtain results[6]. In our assessment, most patients, 41.2%, had ground glass

Table 7
Patient outcomes related to the presence of ground glass opacities.

GROUND GLASS	HOSPITAL DISCHARGE	HOSPITAL DEATH	TOTAL
ABSENT	5 (71.4%)	2 (28.6%)	7(100.0%)
(0%, 25%)	9 (90.0%)	1 (10.0%)	10 (100.0%)
(25%, 50%)	20 (83.3%)	4 (16.7%)	24 (100.0%)
(50%, 75%)	28 (70.0%)	12 (30.0%)	40 (100.0%)
(75%, 100%)	6 (54.5%)	5 (45.5%)	11 (100.0%)
Total	68 (73.9%)	24 (26.1%)	92 (100.0%)

with involvement of 50% to 75% of the surface of the lungs (Tables 3 and 7). Hence, considering that these CT scans were performed in the first days of hospitalization, a high-speed progression of the disease is suggested.

However, it should be noted that the observed imaging findings are not specific or pathognomonic for SARS-CoV-2, but given the observed epidemiological, clinical context, it may corroborate the suspicion. Regarding the necessity for oxygen support, a high need for invasive mechanical ventilation was observed during hospitalizations, required by 41.2% of the patients (Table 5) and only 7.2% did not need any type of oxygen support, which shows a greater severity of the conditions at the time. In addition, the quantification of this alteration was related to the patient's prognosis in this study, in which the chance of patients with ground-glass involvement between 75-100% of the lung evolving to death is twice higher than those with lower lung involvement.

Across the patients, 82% had some comorbidity (Table 1), with a higher prevalence of Hypertension (49.5%), Diabetes (30.9%), and Obesity (23.7%), as shown in Table 2. In this context, the impact of primary prevention of these pathologies is evident, as well as their control, when diagnosed during COVID-19.

Concerning vaccination, its relation to the findings and its impact on pulmonary involvement cannot be evaluated, since most patients did not have a vaccination cycle, due to the unavailability of the input in the period evaluated.

The study has some important limitations. As a result of it being a retrospective study, there was no randomization of the patients, which is an impediment due to ethical factors, and, therefore, there may be intrinsic selection biases in the results. Another deficiency is that despite a significant number of participants (N=97), there is a non-homogeneous distribution between the study groups, which can create distortions. However, there are few studies on the epidemiological profile that the research was carried out, making comparisons difficult. In addition, the lack of data about the control of comorbidities before COVID-19 infection becomes an important selection bias.

CONCLUSION

The results found ratify the hypotheses described in the literature with a significant number of participants (N= 97). Consequently, demonstrating the association of ground glass severity on tomography with worse clinical prognosis for these patients. In addition, it was observed that patients with some of the studied comorbidities had higher mortality. The study did not show an increase in mortality between genders. Considering the limitations discussed, further studies are suggested to confirm the hypotheses raised.

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