Severity Tomographic Score as a Predictor of Mortality in Patients With Covid-19 Pneumonia From a Third-level Hospital in Peru

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Research Article

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Abstract

Objective: Determine whether the tomographic characteristics of patients with COVID-19 pneumonia at the hospital admission and the initial tomographic severity score (TSS) as well as some laboratory tests or clinical characteristics predict mortality.

Methods: Retrospective analytical study that included patients with a clinical diagnosis of SARS-CoV2 virus infection, performed by reverse transcriptase polymerase chain reaction (RT-PCR), serologic reactive test (IgM/IgG) and/or thoracic computed tomography (CT). Patients were divided into two groups: recovered and deceased. Two radiologists (blind evaluators) described the tomographic findings. TSS, clinical and laboratory parameters in relation to mortality were analyzed. Mortality predictions were made by binary logistic regression.

Results: Hypertension was the most frequent associated disease, the most common clinical presentation included cough, discomfort, fever, and dyspnea. The ground glass opacity pattern was the most frequent, followed by consolidation and distortion of the architecture; however, they were not associated with higher mortality. The pattern of pleural effusion and bronchial dilation showed a significant difference from mortality (p <0.05). The binary logistic regression model showed that a moderate and high TSS (≥ 8), as well as a higher degree of lymphopenia, history of asthma and age were associated with an increased risk of death (p< 0.05).

Conclusions: TSS is useful in the initial and comprehensive diagnostic evaluation of COVID-19 pneumonia, in conjunction with markers such as lymphopenia that can predict a poor short-term outcome. A high TSS score is a predictor of mortality.

Introduction

The first case of COVID-19 at our hospital was hospitalized on march 17, 2020 (he died on the second day of admission; he was the first to die in Peru) (1).

According to the National Center for Epidemiology, Disease Prevention and Control of the National Institute of Health, the epidemic behaves very differently in the different regions of Peru; thus, in Lima, mortality and lethality rates are 5.49 x 100'000 inhabitants and 1.81%, respectively (https://www.dge.gob.pe/covid19.html, accessed February 20, 2021).

Of the patients hospitalized for COVID-19 in Peru, about 12% had an unfavorable outcome. Obesity and age over 60 years were the conditions with the highest risk of dying of COVID-19, both are considered independent predictors of in-hospital mortality (2). However, the role of computed tomography as a predictor of the outcome of patients with COVID-19 pneumonia who require hospitalization has not yet been established.
The management of the pandemic by SARS-CoV-2 (COVID-19) had as one of the main axes in the diagnosis of pneumonia, chest computed tomography (CT) defect from emergency admission due to rapid pulmonary imaging compared to delayed molecular test results; allowing, in addition, assessment to categorize the severity of pneumonia.

Imaging diagnosis is essential in cases of SARS-CoV-2 pneumonia. For the initial diagnostic evaluation, chest CT is very useful given its high sensitivity (98%) although low specificity (25%) (3–5). It is not indicated in patients with mild disease unless they are at risk of disease progression (6).

Several classifications have been raised, the Dutch Association for Radiology (NVvR) has proposed a tomographic scoring system for COVID-19, called CO-RADS (COVID-19 Reporting and Data System). CO-RADS provides a level of suspicion of pulmonary involvement of COVID-19 based on the characteristics observed in a non-contrast chest CT; from a very low suspicion (CO-RADS 1) to a very high one (CO-RADS 5). Two additional categories encode one test as technically insufficient (CORADS 0) and one SARS-CoV-2 infection already tested by molecular test at the time of examination (CO-RADS 6) (7). However, this classification is qualitative.

It has also been proposed as a quantitative scoring system with which the tomographic commitment can be measured at the admission of the patient using the "total severity score" (TSS); which is obtained by evaluating the degree of involvement of each of the five lung lobes and is classified as none (0%), minimum (1%-25%), mild (26%-50%), moderate (51%-75%), or severe (76% - 100%). No compromise: score 0; lobe minimum, score 1; lobe mild, score 2; lobe moderate, score 3; and lobe severe, score 4.

TSS is determined by adding the five lobe scores (range of possible scores from 0 to 20) (7,8).

Certain tomographic patterns may be more prevalent in severely ill and deceased patients with COVID19 than in non-serious patients (7). Similarly, the extent or degree of involvement of lung disease can be variable in these two groups of patients. This study determined whether the degree of lung involvement by TSS in patients with COVID-19 pneumonia at the onset of the disease could have any influence on the outcome of mortality (8–10).

Methods

Study design and participants: We conducted a retrospective observational case-control study that included patients diagnosed with COVID-19 pneumonia, admitted during the April-June 2020 period to the Internal Medicine Service of our institution, a third level hospital. The inclusion criteria were patients older than 18 years, with a diagnosis of COVID-19 pneumonia by rt-PCR and rapid serological test positive IgM, according to the national regulations of the Ministry of Health (MINSA) at that time; with non-contrast chest CT with radiological patterns consistent with COVID-19 pneumonia. The cases corresponded to patients whose outcome was death and controls who survived. All patients with an event of death unrelated to COVID-19 were excluded from the study.
The outcome variable was recovery or death of the patient. The main independent variable was the score of the chest CT at admission (TSS). We also analyzed the independent co-variables: age, sex, symptoms on admission, comorbidities: high blood pressure (HBP), diabetes mellitus 2 (DM2), chronic kidney disease (CKD), asthma and obesity. The laboratory data of admission included the absolute number of leukocytes, number of lymphocytes, C-reactive protein, P02, P02, O2 saturation, hospitalization days and CO-RADS classification.

The data were taken from clinical records, epidemiological records and from the central laboratory. The tomographic images of admission were obtained from the hospital tomographic archive.

**CT image acquisition:** The tomographic equipment corresponds to a Philips Brilliance CT scan of 16 cuts (Koniligke, Netherlands), with parameters of 120 kVp; 100–200 mAs; tone, 1–1.5; and collimation, 5 mm and matrix 512 x 512. The images were reconstructed using a medium-sharpness reconstruction algorithm with a cutting thickness of 1 to 3 mm. The images were taken in complete inspiration with the patient in supine decubitus and without administration of contrast. All images were visualized with lung settings (width, 2000 HU; level, -400 HU) and mediastinum (width, 400 HU; level, 40 HU).

Tomographic reading involved the analysis of patients who met the criteria for the study.

**Tomographic evaluation of the patient:** Chest CT scans were described by 2 experienced radiologists (blind evaluators), who included 1) Distribution: presence of peripheral or peribronchovascular lesions;

2) Density: presence of frosted glass opacities, mixed opacities of ground glass or consolidation; 3) Internal structures: presence of airborne bronchogram, thickening of the interlobular septum, cavitation; 4) number of lobes affected by ground glass or consolidations; 5) presence of fibrotic lesions; 6) presence of centrilobular nodules; 7) presence of thoracic lymphadenopathy (defined as lymph node 10 mm in the dimension of the short axis); 9) presence of underlying lung disease such as tuberculosis evaluated, emphysema, or interstitial lung disease.

**Ethical considerations:** The study was authorized by the institutional committee of ethics in research of our institution, no informed consent was required because the data were collected directly from clinical records, epidemiological records, central laboratory and tomographic archive.

**Results**

Of the 203 patients evaluated, 15 not meeting inclusion clinical criteria, 188 were included in the descriptive analysis and only 163 met the selection criteria for the mortality analysis using the binary logistic regression model.

The average age of recovered patients was 55.3 ± 15.6 years, while in dead patients it was 75.8 ± 14.1 years (p<0.001). There were no differences in the proportions by gender in either group (p=0.813). With respect to comorbidities, patients with HBP, CKD and asthma had a higher proportion of mortality in relation to those without such comorbidities (p=0.018, p=0.012, and p=0.036, respectively). In relation to
the laboratory data at admission, there was more lymphopenia and a high level of CRP in the deceased patients compared to those who recovered (p<0.001 and p=0.001, respectively) (Table 1).

In the analysis of symptoms at admission, the most frequent were cough (59.8%), general malaise (51.5%), fever (56.0%) and dyspnea (47.7%). The only symptom associated with the outcome of mortality was sore throat (p=0.012) (Table 2).

The tomographic pattern of “frosted glass” was the most frequent, the pattern of “bronchial dilation” and “pleural effusion” showed a significant difference with respect to the outcome of mortality (p=0.002 and p=0.001, respectively). (Table 3).

With respect to high TSS values (≥8), these were observed in a greater proportion in the group of death (p=0.001) (Figure 1a). Figure 2 shows different levels of pulmonary involvement by COVID-19 and its respective TSS score.

Three multivariate models were created using binary logistic regression (Table 4). Model 1 included all the study co-variables, model 2 included only the significant variables obtained in the first model (TSS score as a numerical variable, number of lymphocytes and age) adjusted for sex. Model 3 replaced the numerical variable TSS score with the categorical variable TSS score (≥ 8 vs <8).

Model 2 shows that the TSS score (adjusted OR=1.27), lymphocyte level (adjusted OR=0.27), age (adjusted OR=1.08), and asthma (adjusted OR=103), are independent predictors of mortality in patients with COVID-19 pneumonia. Of these variables, asthma has a very wide IQ; so its value as a predictor of mortality is unclear. Model 3 included the TSS score as a categorical variable (8 vs <8), which was not a predictor of mortality due to COVID-19 pneumonia.

With model 2, a graph was designed to estimate the predictive margins according to TSS score values at hospitalization. (Figure 1b)

Only the pattern of pleural effusion and bronchial dilation showed a significant difference with respect to the outcome, however, this difference could be due to the low frequency of presentation of such patterns.

**Discussion**

Some significant differences were found in certain clinical and laboratory parameters to predicting mortality from COVID-19, such as age, high blood pressure, chronic kidney disease, asthma, low lymphocyte level, and elevation of C-reactive protein. These factors have been previously studied and influence the outcome of mortality by COVID-19 (11–13).

The only comorbidity that was found to be significant as a predictor of mortality was asthma, however, its wide confidence interval suggests that the few cases included in the study do not robustly support this result. In most published studies on comorbidities, severe asthma was associated with greater severity in patients with COVID-19 pneumonia (14). Likewise, obesity, also studied as one of the main comorbidities
associated with mortality (15–19), could not be rigorously evaluated in this study due to the small number of patients with this comorbidity.

Age is a critical factor in this disease. As in most previous studies at the beginning of the pandemic, it was evident that the older the age, the higher the mortality (14,17). Most studies have proposed 60 years as an important cutoff point (17); in our study, the average age was 60 ±17.5 years. Also, an important finding in our study was that arterial hypertension was associated with a greater hospital stay, a comorbidity that is known as a risk factor for severe Covid pneumonia.

In relation to laboratory examinations, lymphopenia was associated with higher mortality. Several studies have shown that lymphopenia or lymphocyte/neutrophil ratio predicts greater severity (13,20).

It is important to evaluate this parameter because the blood count is one of the essential tests and easily accessible to most of the population, especially in low-income countries like ours, in which there are often diagnostic limitations. Regarding CRP, its initial value was significant in the bivariate mortality analysis. This is consistent with many other studies in which it was shown as an important prognostic factor when evaluated from the patient's admission (21).

The usefulness of the TSS score as a predictor of mortality has been described, showing that a high TSS value is associated with higher mortality (22). In terms of tomographic patterns, it has been reported that the "crazy paving" and consolidation pattern could be related to a poor short-term prognosis (23), in our study, bronchial dilation and pleural effusion suggest a relationship with the outcome of mortality. Some authors found a correlation between laboratory markers and chest CT (6,22,24,25), similarly in our study, CRP, lymphopenia and the TSS score are related to increased mortality and may help classify severe patients early (23,26), even if the molecular test is not available or is negative at the time of hospital admission (27–29).

In conclusion, the TSS score may be a useful instrument at the beginning of the diagnosis of COVID-19 pneumonia in conjunction with the comprehensive evaluation of the patient’s chest CT at hospital admission, and with markers such as lymphopenia and elevated CRP, having the latter the ability to predict a bad evolution in the short term. Our study shows that a high TSS score is a predictor of mortality and arterial hypertension is a factor that predicts the increase in days of hospital stay.

**Declarations**

**Contributions of authorship:**

**JRH** has participated in the conception, data collection, design, analysis and interpretation of data, review of the article, approval of the final version and technical or administrative advice; **UCB** have participated in the design, data collection of the article, analysis and interpretation of data, critical review of the article, and approval of the final version; **CBN** and **SMT** have participated in the design, analysis and interpretation of data, critical review of the article, and approval of the final version; **MEV** has participated
in article data collection and approval of the final version; **WAQ** has participated in statistical analysis and interpretation of results, critical review of the article and approval of the final version; **EQA** has participated in analysis and interpretation of tomographic images and approval of the final version.

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**Conflicts of interest statement:** The authors declare that they have no conflicts of interest.

**References**


**Tables**

Tables 1 to 4 are available in the Supplementary Files section

**Figures**
Figure 1

A) Distribution of the TSS score according to the outcome of the patients. Recovered (blue) has a median of 6 on the TSS score and Death (orange) has a median of 10 on the TSS score. B) Predictive margins (95% CI) for the probability of death according to the TSS score at hospital admission for patients with COVID-19 pneumonia, based on the logistic regression model, adjusted for sex and age.
Figure 2

Three levels of severity of COVID-19 in thorax tomography images of 3 different patients. In images A and B, two small-consolidation foci and tarnished glass of subpleural distribution in the right hemithorax are shown, this patient had a TSS score of 4. Images C and D show consolidation foci in both lung bases and areas in tarnished glass of central and subpleural distribution at the height of the aortic arch; had a TSS score of 8. Images E and F show extensive involvement with a tarnished glass patron of the lower lobes of both lungs and upper lobe basal segments; it had a TSS score of 12.

Supplementary Files
This is a list of supplementary files associated with this preprint. Click to download.

- Tables.docx