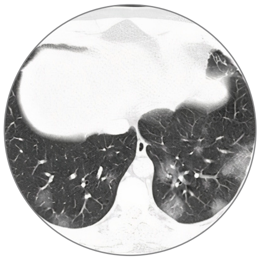


Covid-19: development and results of a CT puntaje admission chest CT predictive value

COVID-19: desarrollo y utilidad de un Puntaje-TC valor predictivo de la tomografía de ingreso

Sebastián Pérez Espinosa[1]
Rodolfo Fernández[2]
Nicolás Bonini[3]
José Campo Torrenegra[4]
Paola Rojas Ibáñez[5]
Carolina Delgado[6]
Claribel Balsano[7]

Key words (MeSH)

Coronavirus infections
Multidetector computed tomography
Pneumonia
Outcome and process assessment, health care

Palabras clave (DeCS)

Infecciones por coronavirus
Tomografía computarizada multidetector
Neumonía
Evaluación de procesos resultados en atención de salud

[1]Physician specialized in Diagnostic Imaging, Head of Diagnostic Imaging Division, Hospital Ramos Mejía. Buenos Aires, Argentina.

[2]Physician specialized in Internal Medicine, Chief of Division "A" Medical Clinic, Hospital Ramos Mejía. Buenos Aires, Argentina.

3. Doctor specialized in Internal Medicine, Chief of Section "A2" Medical Clinic, Hospital Ramos Mejía. Buenos Aires, Argentina.

[4]Physician specialized in Diagnostic Imaging, Chief of Imaging Diagnostics, Hospital Ramos Mejía. Buenos Aires, Argentina.

[5]Physician specialist in Diagnostic Imaging, Hospital Ramos Mejía. Buenos Aires, Argentina.

[6]Doctor specialist in Internal Medicine, ward "A2" Hospital Ramos Mejía. Buenos Aires, Argentina.

[7]Doctor resident 4 years, Diagnostic Imaging, Hospital Ramos Mejía. Buenos Aires, Argentina.

Summary

Purpose: To create a CT Score to objectively and quantitatively predict the severity and evolution of COVID-19 pneumonia in concordance with unenhanced upon admission chest CT findings. ***Material and Methods:*** We retrospectively evaluated 98 patients with a diagnosis of SARS-CoV-2 confirmed by RT-PCR admitted to the general ward. We developed a CT score to quantify the imaging involvement of the disease at hospital admission. This score values the type of patterns and the total burden of the lesion (expressed as a percentage of the parenchymal involvement). A Receiver Operating Characteristic (ROC) curve analysis was performed as a test of diagnostic accuracy of the developed Score. ***Results:*** 98 patients were analyzed, using as cut-off point a CT score puntaje ≤ 14. No patients with unfavourable evolution were detected (100 % Negative Predictive Value, 80 % sensitivity, 100 % specifity to predict favourable development). CT Score < 22 (91.2 % Negative Predictive Value for the need of oxygen reservoir masks and 94.7 % for unfavourable outcome). A CT Score ≥ 22 predicted a need for oxygen therapy and unfavourable development. (92.6 % Positive Predictive Value, 80 % sensitivity and 65 % specificity). The area under curve (AUC) was 0.8197, which makes it a test with a high diagnostic discriminatory capacity. ***Conclusion:*** CT Score is useful to determine the radiological assessment of pulmonary involvement in three grades: minor, moderate and severe. The imaging findings are highly correlated with clinical evolution variables. It can be considered an important tool for prognostic value and to adapt early and timely therapeutics behaviours in the development of this illness.

Resumen

Propósito: Crear un puntaje-TC para predecir de manera objetiva y cuantitativa la gravedad y evolución de la neumonía por COVID-19 en concordancia con los hallazgos de la TC de tórax sin medio de contraste al ingreso. ***Métodos y materiales:*** Se evaluaron retrospectivamente 98 pacientes con diagnóstico de SARS-CoV-2 confirmados por RT-PCR internados en sala general. Se desarrolló un puntaje tomográfico para cuantificar el compromiso imagenológico de la enfermedad al ingreso al hospital, valorando tipo de opacidades y volumen del parénquima afectado. Se realizó un análisis de curva ROC (Receiver Operating Characteristic) como prueba de exactitud diagnóstica del puntaje desarrollado. ***Resultados:*** Se analizaron 98 pacientes, utilizando como punto de corte un puntaje-TC 14, no se detectaron pacientes con evolución desfavorable (VPN 100 %, sensibilidad 38 % yespecificidad 100 % para predecir una buena evolución). Un puntaje-TC < a 22 (valor predictivo negativo [VPN] de 91,2 % para máscara con reservorio de oxígeno y de 94,7 % para evolución desfavorable). Un puntaje-TC 22 (valor predictivo positivo [VPP] de 92,6 % para necesidad de utilización de oxígeno) se asoció a mala evolución (sensibilidad del 80 % y especificidad del 65 %). El área bajo la curva fue de 0,8197, lo que lo constituye en una prueba con buena capacidad discriminatoria diagnóstica. ***Conclusión:*** El puntaje-TC desarrollado es un método sencillo, reproducible y sumamente útil en la valoración de pacientes con diagnóstico de infección por SARS-COV-2, ya que caracteriza el compromiso pulmonar tomográfico en leve, moderado y grave, con una marcada correlación con las variables de evolución clínica. Puede tener un importante valor pronóstico y adecuar conductas terapéuticas precoces y oportunas en la evolución de la enfermedad.

1. Introduction

In December 2019, a series of pneumonia cases were reported, apparently originating from an animal and seafood market in Wuhan, Ubei, China. Rapidly coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome (SARS-CoV-2), spread to several countries around the world, reaching a pandemic stage in March 2020 (1, 2). Humanity is facing a serious crisis, declared a public health emergency by WHO on January 20, 2020 (3).

The spread of COVID-19 has been heterogeneous. This has resulted in some regions having sporadic transmission and relatively few hospitalized patients with COVID-19, and others having community transmission, resulting in an overwhelming number of severe cases (4). Although mild cases mimic viral upper respiratory tract infections, respiratory dysfunction becomes the main source of morbidity and mortality in severe cases (5).

Although different vaccines against COVID-19 exist to date, there is still no effective treatment (6). It should be clarified that at the time of the development and analysis of this study, vaccines were still under research, so that prevention measures applied through public policies and early diagnosis were the only tools available. Among them, diagnostic imaging played a key role in the assessment and follow-up of this entity, with special interest in computed tomography (CT), given its high sensitivity in the early stages of the disease, its wide availability and its speed of acquisition (1, 7).

Due to the exponential increase of cases and the marked demand for beds in isolation wards, admission CT was sought as a predictor of severity in the evolution of the disease, with the aim of taking early measures, such as defining the possibility of home isolation, admission to a general ward or predicting the need for an intensive care unit.

Taking into account that ground-glass opacities, interstitial alteration and the development of consolidation are present in patients with SARS-CoV-2 lung involvement (8, 9), a CT-score was developed to assess the type of opacities and the extent of parenchymal involvement, with a value for each patient ranging from 0 to 54.

The present study summarizes the clinical and radiological characteristics and evolution of 98 patients with a confirmed diagnosis of COVID-19 infection. The following variables were considered as variables of evolution: oxygen therapy indication, requirement of oxygen reservoir mask and need for transfer to the intensive care unit due to hypoxemia or high risk of death.

Each patient's admission CT was assessed with the previously developed CT-CT score. A Receiver Operating Characteristic (ROC) curve was made to evaluate the usefulness of the diagnostic test and its predictive value with respect to the evolution variables considered.

2. Objectives

- To describe the clinical characteristics, history and evolution of the population.
- To analyze the findings in the admission chest CT scan.
- To develop a CT-score and to evaluate its usefulness as a prognostic of evolution.

3. Materials and Methods

3.1. Population

A retrospective, observational study was carried out on 98 hospitalized patients with a confirmed diagnosis of COVID-19 infection (by RT-PCR), during the period from June 15 to July 31, 2020, who underwent chest CT on admission, after consultation in the emergency febrile units (UFU).

3.2. Inclusion criteria

- Age: over 18 years old
- Hospitalization with recent diagnosis of COVID-19 by RT-PCR.
- CT scan performed on admission. Criteria for CT scan on admission: respiratory semiology and/or desaturation and comorbidities (diabetes, obesity, HT, COPD, or age over 65 years).

3.3. Exclusion criteria

Comorbidity or concomitant disease to COVID-19 that conditions the prognosis and/or the limitation of therapeutic measures (advanced senescence, dementia, complication of another pre-existing pathology).

3.4 Definitions

- Diagnosis of HT: Patients with known diagnosis or need for treatment during hospitalization.
- Diagnosis of diabetes: Patients with known diagnosis or need for pharmacological treatment during hospitalization.
- Diagnosis of obesity: BMI > 30 kg/m2.
- Febrile behavior: Temperature readings greater than 37.5 during hospitalization.
- Conventional oxygen therapy: Use of nasal cannula or Venturi mask.
- Refractoriness to conventional oxygen therapy: Need for reservoir mask.
- Unfavorable evolution: Need for transfer to a closed unit due to refractory hypoxemia or high risk of death.
- UFU: Emergency febrile units.

3.5. Treatment

The hospitalized patients were treated according to current protocols which included: antibiotic therapy, dexamethasone, oxygen therapy and therapies indicated according to the criteria of the treating medical team.

3.5.1. Evolution Variables

- Clinical stability without compromised blood gas.
- Need for oxygen therapy by conventional methods (nasal cannula or Venturi mask).
- Requirement of oxygen therapy with oxygen reservoir.
- Unfavorable evolution and transfer to intensive therapy unit for hypoxemia refractory to treatment or high risk of death.

3.6. CT acquisition technique

The CT scans were performed in a Siemens 16-slice machine with high-resolution reconstructions of 2.5 mm thickness with a 2-mm interval; images were obtained in the axial, coronal and sagittal planes. All examinations were performed with patients in the supine position and with maximum inspiration, without the administration of intravenous contrast medium. A window was used for mediastinal (L:50 W:400) and lung parenchyma (L:-600 W:1070) assessment.

The images were available for real-time consultation through a PACS system that provides visualization of the images in the radiology room, in the UFU offices and in the isolation rooms.

CT images were evaluated for the presence and distribution of parenchymal abnormalities such as "ground-glass" or cobblestone pattern (also known as crazy-paving) and consolidation. Additionally, the presence of mediastinal adenomegaly and pleural effusion was evaluated. Hilar adenomegalies were not evaluated because the studies were performed without contrast medium.

The distribution of the lesions as central, peripheral or both and their distribution in upper, lower, middle or multiple lobes were taken into consideration.

The characteristic images are shown in Figure 1.

4. Categorization of the images (CT-score)

The CT radiological reports currently performed are purely descriptive. Although they allow linking characteristic imaging findings to SARS-CoV-2 infection, they do so in a qualitative manner; thus, they offer limited usefulness in defining prognosis and tailoring therapeutic behavior. A CT-score was developed based on the type of radiological findings observed in each lung lobe independently, and summed with the percentage they occupied within the parenchyma.

The scale on the severity of the lesions was categorized into 4 variables, with a value of 0 for normal parenchyma, 1 for ground-glass opacities (GCO), 2 for opacities with cobblestone-like pattern and 3 for consolidations. A score was also given to the percentage that each of these lesions occupies within a pulmonary lobe, with a 4-point scale, where < 25 % equals 1 point; from 25 % to 50 %, 2 points; 50 % to 75 %, 3 points; > 75 %, 4 points. This score is summarized in Table 1.

Table 1. Score-TC Score

Score		Porcentage	
Normal	0	< 25 %	1
Ground glass	1	25 – 50 %	2
Cobblestone	2	50 – 75 %	3
Consolidation	3	> 75 %	4

The radiological patterns commonly present according to the chronology of the disease are exemplified in Figure 2.

The expected initial findings correspond exclusively to "ground-glass" opacities. Considering that CT scans were performed at hospital admission, early detection of disseminated opacities, interstitial involvement and consolidation could be linked to severity indicators.

Finally, the values obtained for each of the lobes in both lungs were summed and a final score was obtained. The scale of possible values was from 0 to 54 points. The images obtained were evaluated jointly by two physicians specialized in diagnostic imaging, who, unaware of their clinical parameters and based on consensus, assigned a score to each CT scan. The examples are plotted in Figures 3, 4 and 5.

5. Statistical Analysis

Continuous variables were expressed as median (interquartile range, IQR) and compared with the Mann-Whitney U test or the Wilcoxon test; categorical variables were expressed as number (%) and compared with the $\chi 2$ test or Fisher's exact test, if applicable. A bilateral α of less than 0.05 was considered statistically significant. Statistical analyses were performed using SPSS (version 16.0). Data analyses are subject to the stipulations of the Nuremberg and Helsinki Codes on Biomedical Research Involving Human Subjects.

6. Results

Four patients were excluded because they had concomitant pathologies that independently conditioned their prognosis (Hodgkin's lymphoma, dementia, abdominal stab wound and myasthenic crisis).

Mean age was 51.7 years +/- 16.5. Male sex 74.5 %.

61.2 % of the patients had some comorbidity. The prevalent ones were = obesity (29.6 %); arterial hypertension (27.6 %); diabetes (23.5 %); asthma (6.1 %), and COPD (3.1 %). Of the patients, 32.7 % had febrile behavior during hospitalization.

The median onset of symptoms at the time of consultation and CT scan was 5 days (R:0-14). The characteristics of the population are summarized in Table 2 and Figure 6.

Table 2. Characteristics of the studied population

Variables	Patients (*n* = 98)
Age	51.7 (+/- 16.5) %
Sex male	74.5 %
Comorbidities	61.2 %
Obesity	29.6 %
Arterial hypertension	27.6 %
Diabetes mellitus	23.5 %
Chronic obstructive pulmonary disease	3.1 %
Asthma	6.1 %

Figure 1. a) Opacities with "ground-glass" pattern: increased attenuation values, without effacement of vascular structures. b) Opacities with cobblestone pattern: "ground-glass" opacity associated with thickening of the interlobular septa. c) Consolidation over the posterior segment of the right upper lobule, there is an effacement of the vascular structures associated with air bronchogram over an area of ground-glass opacity.

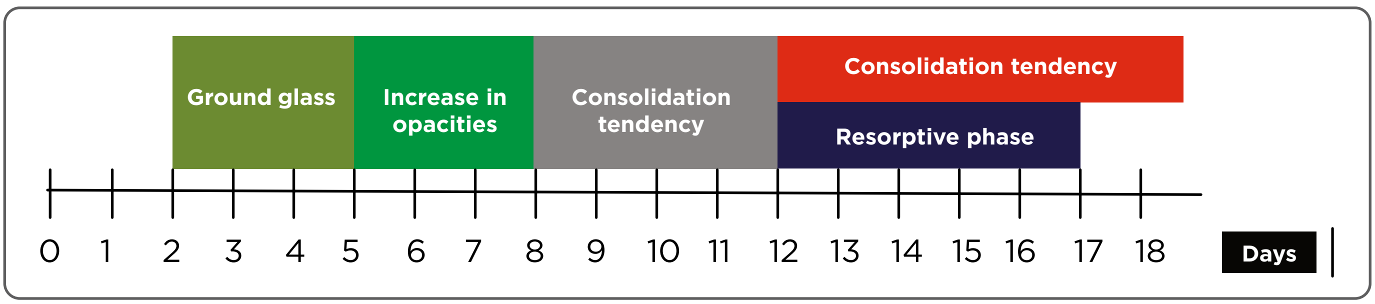


Figure 2. Chronological evolution of tomographic images in COVID-19 infection.

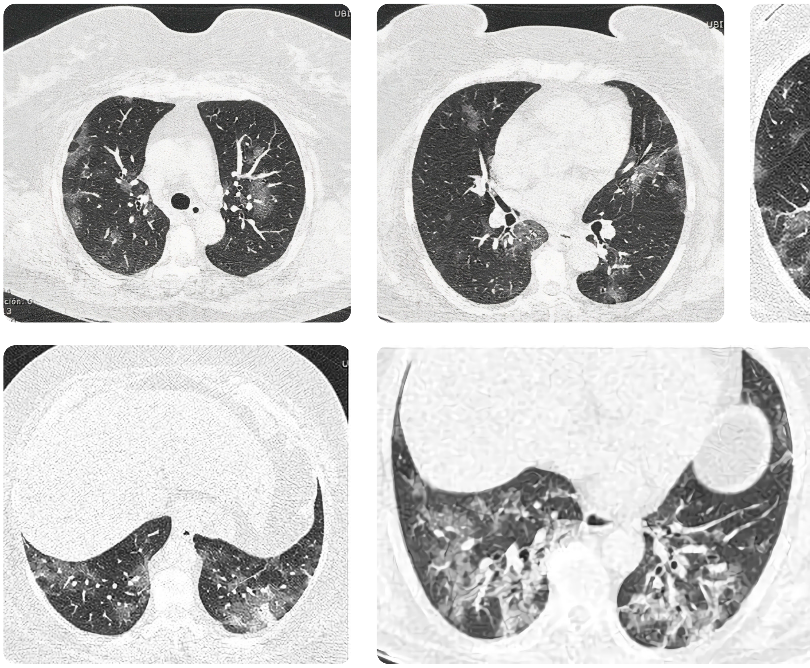
Left lung

Lobe	Normal	G-G	%	CP	%	CONS	%
Upper	0						
Middle		1	1				
Lower		1	1				

Right lung

Lobe	Normal	G-G	%	CP	%	CONS	%
Upper		1	1				
Middle		1	1				
Lower		1	1				

Figure 3. CT-score in a 32-year-old male patient. Absence of opacities in the right upper lobe. Ground-glass" pattern in the right middle and inferior lobes, both < 25%. In the left upper lobe and the lagula, ground-glass opacities < 25% and finally in the left lower lobe, ground-glass opacities of 25%-50%. Total score 11.



Left lung

Lobe	Normal	G-G	%	CP	%	CONS	%
Upper		1	1				
Middle		1	1				
Lower		1	2				

Right lung

Lobe	Normal	G-G	%	CP	%	CONS	%
Upper		1	1				
Middle		1	2				
Lower		1	3			3	1

Figure 4. CT-score in a 50-year-old female patient. Ground-glass opacity <25% is visualized in the right superior and middle lobes. The right inferior lobe also shows ground-glass opacity, but occupying 25-50%. In the left upper lobe, ground-glass opacity is observed in < 25 %, while in the lower lobe and the lower lobe ground-glass opacity is observed in 25-50 %. In addition, the left inferior lobe was associated with consolidation < 25 %. Total score 19.

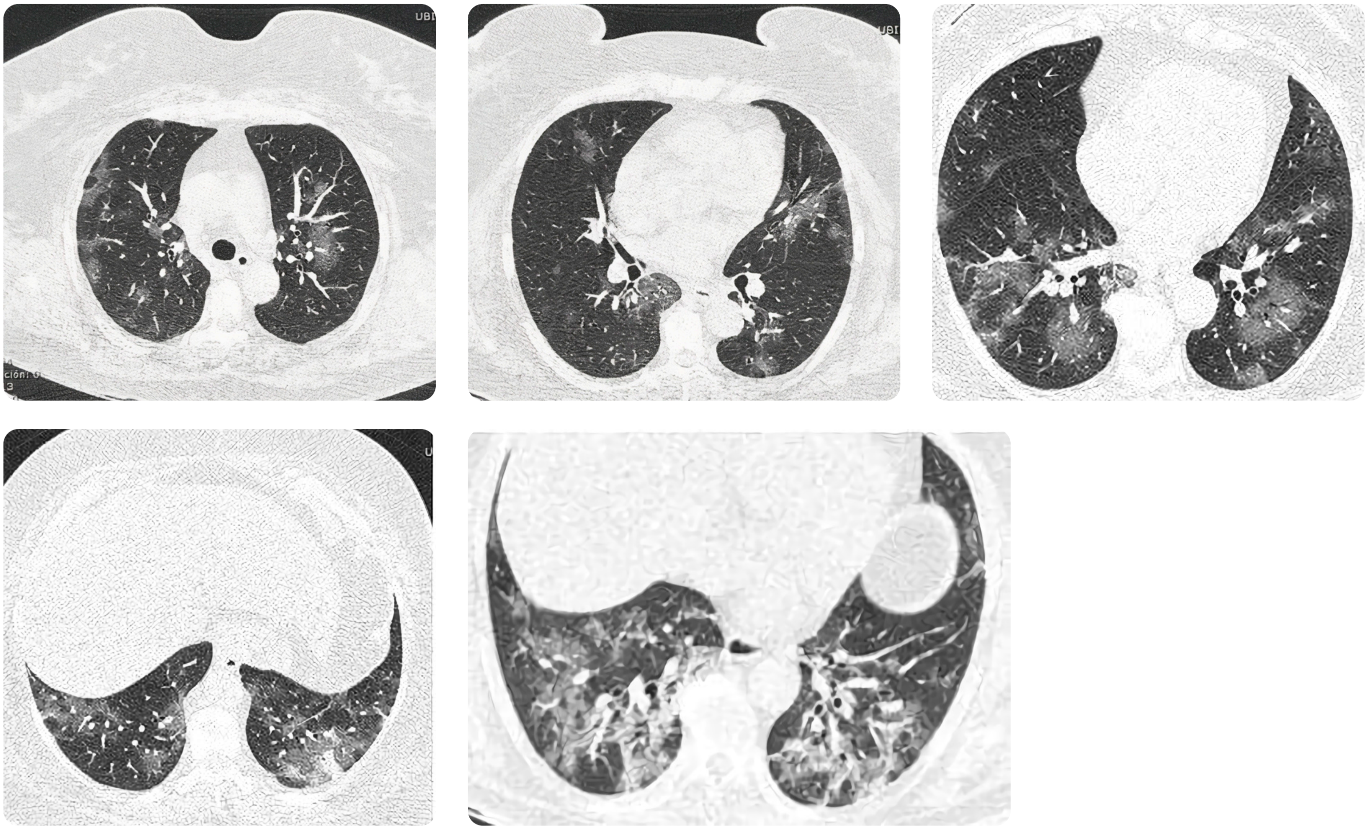
6.1. Evolution

Four groups of evolution were determined (n = 98):

1. Clinical stability without compromised blood gas (36.7 %).
2. Use of oxygen therapy by conventional methods (nasal cannula or Venturi mask) (38.7 %).
3. Requirement of oxygen reservoir mask (9.1 %).
4. Unfavorable evolution and transfer to the intensive care unit due to hypoxemia refractory to treatment or high risk of death (15.3 %) (Table 3).

Table 3. Evolution groups

Variable	No need for oxygen	Conventional oxygen	Reservoir	Poor evolution	Statistical analysis
	***n* = 36**	***n* = 38**	***n* = 9**	***n* = 15**	
Male sex	25 (69,4 %)	28 (73,7 %)	8 (88,9 %)	12 (80 %)	N5
Age	48,4 +/- 19,9	54,9 +/- 16,1	49,1 +/- 9,5	52,9 +/- 10,2	N5
Comorbidity	17 (47,2 %)	27 (71,1 %)	6 (66,7 %)	10 (60 %)	
Comorbidity by groups	47,20 %	69,40 %			Fisher: p = 0,025
Diabetes	9 (25 %)	9 (23,7 %)	7 (77,8 %)	3 (20 %)	
Hypertension	12 (33,3 %)	10 (26,3 %)	1 (11,1 %)	4 (26,7 %)	
Obesity	4 (11,1 %)	14 (36,8 %)	6 (66,7 %)	5 (33,3 %)	



Left lung

Lobe	Normal	G-G	%	CP	%	CONS	%
Upper		1	3			3	2
Middle		1	2				
Lower		1	2				

Right lung

Lobe	Normal	G-G	%	CP	%	CONS	%
Upper		1	2				
Middle		1	2			3	1
Lower		1	3			3	1

Figure 5. CT-score in a 48-year-old male patient. Ground-glass opacities are visualized in the right lung, with a compromise of 50%-75% in the upper lobe; this lobe also shows consolidation involving 25%-50%. In the middle and lower lobes, "ground-glass" opacity, but 25-50%. In the left lung, ground-glass opacity involving 25%-50% of the superior lobe and lingula and 50%-75% of the inferior lobe. Likewise, the lagula and inferior lobe present areas of consolidation < 25 %. Total score 33.

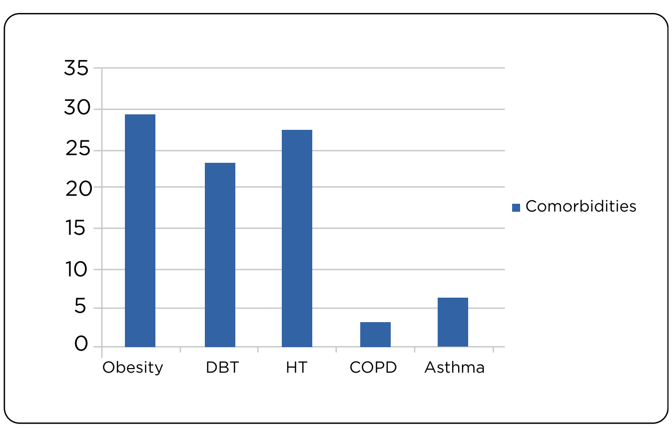


Figure 6. Comorbidities of the studied population

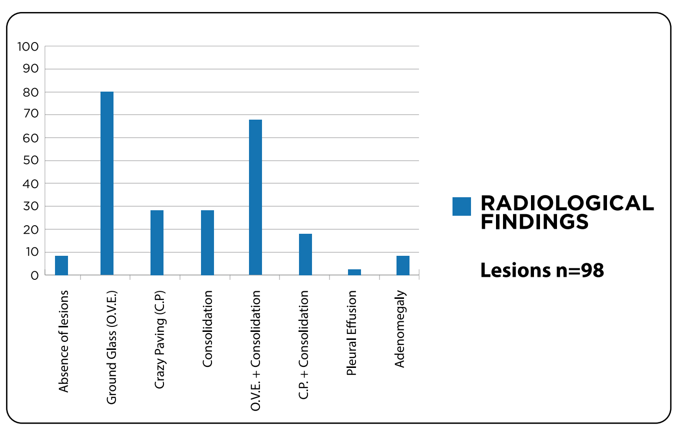


Figure 7. Radiological findings in the population studied.

Age was evaluated as an independent variable with respect to the evolution of the patients. No significant differences were found.

Patients requiring oxygen (groups B, C and D) had a higher prevalence of comorbidities compared to those who did not require oxygen (69.4 % vs. 47.2 %; p=0.025). Obesity was prevalent in those patients requiring oxygen (groups B, C and D vs. group A) (40.3 % vs. 11.1 %; p=0.0016); as well as in the group of patients requiring a reservoir mask compared to those who did not (groups C and D vs. A and B) (37.9 % vs. 18.8 %; p=0.042) (Table 4).

Table 4. Prevalence of obesity in patients with poor outcome

	Group A	Group B	Group C	Group D
Obesity by group	11,10 **%**	40,30 **%**		
Obesity by group	18,80 **%**		37,90 **%**	

6.2. CT-Score

The population was evaluated with the developed CT-score. The median was 20, range 0-46, P25-75, 11-26; n 98) (Table 5).

Table 5. Scoring by CT-score in the population studied

CT-score	Minimum	P25	Median	P75	Maximum
CT-score	0	11	20	26	46
CT-score in non-obese	0	6	17	23	46
CT score in obese	10	20	22	28	42
Kruskal-Wallis:p = 0,0016					

In the group of patients with obesity, higher CT-score values were recorded compared to the non-obese population. It was interpreted as an expression of greater pulmonary involvement of the disease (median 22, R: 10-42 vs. median 17, R: 0-46; p = 0.0016).

This finding was not evident in the rest of the comorbidities individually or in the sum of the comorbidities.

6.3. Radiological findings

The most frequent findings in the population studied (n = 98) were ground-glass opacities (82.7 %), cobblestones (30.6 %) and consolidation (29.4 %).

The association of "ground glass" plus consolidation was the most frequent, 67.9 %, and to a lesser extent the pattern of cobblestone plus consolidation (21.4 %) (Figure 7).

The presence of opacities did not have a preferential involvement, involvement of upper, middle, lower lobes or with multiple compromise was observed in 72.4 % of the cases (figure 7), in 17.4 % no acute lesions were found in the pulmonary parenchyma (n = 98) (figure 7).

The location of the lesions was peripheral distribution, 46 % or mixed 54 %. There were no lesions of purely central distribution (n = 98) (Figure 8).

Mediastinal adenomegaly and pleural effusion were infrequent (Figure 7).

6.4. Progression indicators

Evaluation according to conventional tomographic findings: In patients with need for oxygenation with respect to those who did not require it, "ground glass" opacity (90.3 % vs. 69.3 %); cobblestoning (43.5 % vs. 8.3 %); consolidation (69.4 % vs. 47.2 %); and multiple lumen involvement (90.3 % vs. 41.7 %) prevailed with statistical significance. The finding is interpreted as an indicator of COVID-19 disease with higher-ranking clinical involvement (Table 6).

Table 6. Characteristics and distribution of the tomographic findings

Ground-glass opacity	25 (69,3 %)	34 (89,5 %)	8 (88,9 %)	14 (93,3 %)	
	69,30 %		90,30 %		Test de Fisher: *p* = 0,01
Cobblestone	3 (8,3 %)	13 (34,2 %)	5 (55,6 %)	6 (60 %)	
	8,30 %		43,50 %		Test de Fisher: *p* = 0,00015
Consolidation	17 (47,2 %)	25 (65,8 %)	7 (77,8 %)	11 (73,3 %)	
	47,20 %		69,40 %		Test de Fisher: *p* = 0,025
Multiple Lobes	15 (41,7 %)	33 (86,8 %)	9 (100 %)	14 (93,3 %)	
	41,70 %		90,30 %		Test de Fisher: *p* = 0,00000035

Evaluation according to CT-score: The score of the CT-score was significantly higher between each progression group (A: no need for oxygen; B: use of conventional oxygen therapy; C: requirement of mask with reservoir; D: unfavorable progression). Thus, the CT-score was considered an indicator of disease severity by COVID-19 (Table 7 and Figure 9).

Table 7. Evaluation by groups according to CT-score

	Group A	Group B	Group C	Group D
CT-score (Median/ Range)	9 (0-26)	20,5 (0-41)	24 (14-39)	28 (15-46)
CT-score (oxygen yes or no)	9 (0-26)	22,5 (0-46)		
CT-score (reservoir yes or no)	17,5 (0-41)		28 (14-46)	
CT-score (poor evolution yes or no)	19 (0-41)			28 (15-46)
				(K. Wallis < 0,00001)

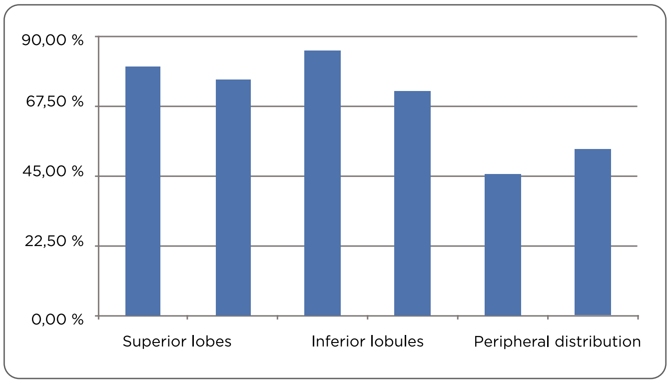


Figure 8. Distribution of lesions in chest CT.

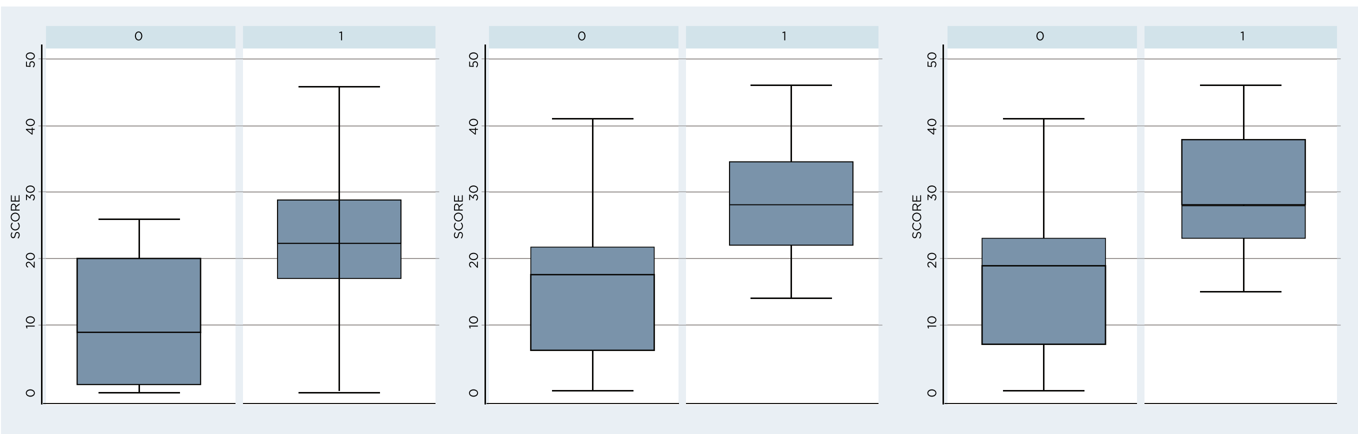


Figure 9. CT-score in patients with need of oxygen, scar reservoir and poor evolution vs. control.

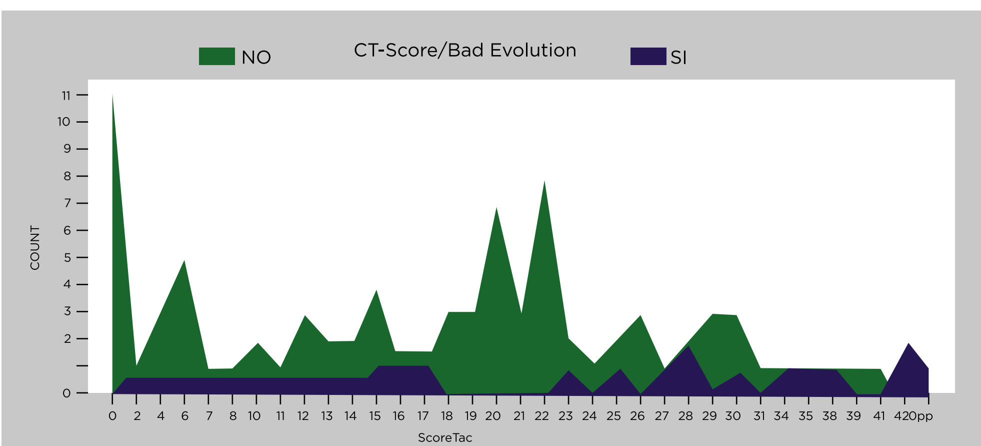


Figure 10. CT-score in patients with favorable (green) and unfavorable (blue) evolution.

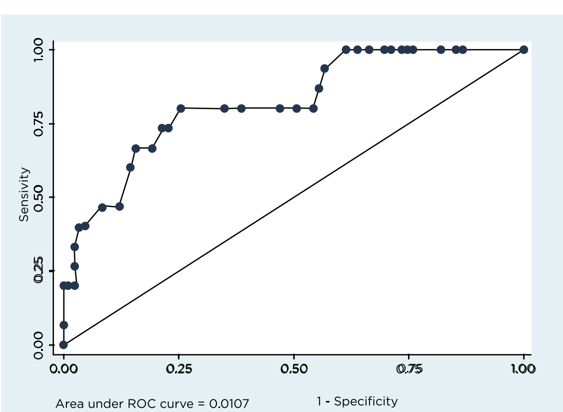


Figure 11. Graphical representation of the ROC curve of the diagnostic test.

The value of the CT-score was significantly higher in patients with unfavorable evolution with respect to the rest of the population. Median 28 (R: 15-46) vs. 19 (R: 0-41) (p < 00001) (Figure 10).

6.5. Utility of the CT-score

A ROC curve analysis was performed as a test of diagnostic accuracy of the developed score. The area under the curve was 0.8197, which constitutes a test with good diagnostic discriminatory capacity (Figure 11).

7. Progression indicators (conventional CT evaluation vs. CT-score)

7.1. Indicators of mild disease

- **Conventional CT evaluation:** No consolidation was found in the CT of 38.7% of the patients. In this group the need for reservoir oxygen reached a NPV of 75.5 %. In 27.5 % of the cases no multiple lobe involvement was found. In these patients the NPV of the need for reservoir oxygen was 96.2 %. In this group of patients there were no cases of unfavorable evolution.

  The absence of consolidation and involvement of multiple lobes was interpreted as an expression of mild disease by COVID-19, due to the management with conventional oxygen therapy and the fact that there were no cases of unfavorable evolution (NPV = 100 %). This situation was evidenced in 17.3 % of the patients, with a poor sensitivity (22.9 %) for detecting patients with good evolution.
- **Assessment with CT-score:** CT-score values ≤ 14 were found in 32.7 % of patients, reaching a sensitivity of 38.5 % and specificity of 100 % for favorable evolution. Only one patient in this group required an oxygen reservoir mask (NPV 95.8 %).

  Considering the favorable evolution indicators mentioned above, the CT-score achieved greater sensitivity than conventional tomographic evaluation, allowing the detection of a greater number of patients with favorable evolution.

7.2. Indicators of moderate to severe disease

- **Conventional CT evaluation:** The tomographic findings of ground glass, cobblestone, consolidation and multiple-lobe compromise were each independently associated with the need for oxygen as an indicator of at least moderate disease (Table 8).

  Among those who needed oxygen (n = 62) vs. group A (n = 36) the presence of “ground glass” opacity was 90.3 % vs. 69.3 %; consolidation 69.4 % vs. 47.2 % and multiple pules involvement 90.3 % vs. 41.7 %, with a PPV (positive predictive value) of needing oxygen of 69.1 %; 71.6 % and 78.8 %, respectively.
  The presence of cobblestoning (3.5 % vs. 8.3 %) among oxygen users was the indicator with the highest PPV of need for oxygen therapy, yielding 91.6 %. However, these findings were found in only 30.6 % of the patients, thus presenting a sensitivity of 43.5 %.

  Assessment with CT score: CT score values ≥22 were found in 41.8 % of patients. Evaluating the need for oxygen as an ex-pression of severe disease, sensitivity was found to be 59.6 %, with a PPV of 90.2 %.
  The reservoir requirement in the group of patients with Score-TC ≥22 reached sensitivity: 79.1 % and specificity: 70.2 %. Evaluating unfavorable evolution, sensitivity: 80 % and specificity:65%.
  The finding of a Score-TC <22 was associated with a NPV of 91.2 % for the need for a reservoir mask and 94.7 % for unfavorable evolution as indicators of non-critical disease.

8. Discussion

Coronaviruses (CoV) correspond to a large family of respiratory viruses that can cause from banal to severe disease, such as severe acute respiratory syndrome (SARS-CoV) in 2002, or middle east respiratory syndrome (MERS-CoV) in 2012. The new coronavirus (SARS-CoV-2) corresponds to a strain that had not previously been identified in humans (10, 11) and that has similar symptoms to SARS according to recent clinical data (2, 12). It is a pathology that currently has no specific treatment (6).

Consistent with recent publications, the results of the present study suggest that SARS-CoV-2 is more likely to occur with poor outcome and death in patients with chronic comorbidities as a result of their weaker immune functions (2, 10, 12). It should be noted that patients with obesity presented higher values in the CT-score than those with other comorbidities.

The tomographic findings in the early diagnosis of the disease play a key role in the categorization of patients infected with COVID-19 pneumonia. The results described here showed that the usual manifestations were predominantly “ground-glass” opacities (82.7 %) mixed with consolidations (67.9 %), mainly with peripheral (46 %) or combined peripheral and central (54 %) distribution.

Table 8. Conventional Assessment of CT Findings

Findings	Patients without oxygen (36)	Patients with oxygen (62)	Sensitivity	Specificity	PPV	Fisher’s test
Opacity on ground glass	69.3 %	90,3 %	90.3 %	30.5 %	69.1 %	0.01
Cobblestone	8.3 %	43,5 %	43.5 %	91.6 %	90 %	0.00015
Consolidation	47.2 %	69,4 %	69.4 %	52.7 %	71.6 %	0.025
Multiple lobes	41.7 %	90,3 %	88.7 %	58.3 %	58.3 %	0.00000036

Pulmonary involvement was slightly more frequent in lower lobes (85.7 %), with multiplicity of lobes (72.4 %). There was a low prevalence of pleural effusion and/or mediastinal adenomegaly. In those who presented pleural effusion, these were mild; and as for mediastinal adenomegalies, they presented a mean of 12 mm in their short axis. Given the low prevalence of these findings, the low association of these entities with acute pulmonary infection caused by SARS-CoV-2 could be inferred.

The extensive distribution of the opacities, the existence of early consolidation, as well as the presence of multiple involved lung areas were more common in the group of patients with poor outcome. This suggests a more severe clinical course for these anomalies, a finding that can be correlated with diffuse alveolar damage, and which may be similar in other viral infections (such as H1N1 pneumonia, H5N1 pneumonia, H7N9 pneumonia and SARS) (2, 13).

Although a definitive diagnosis of COVID-19 pneumonia cannot be reached using CT images alone, most viral pneumonia image patterns share similarities. The features summarized above could be useful in differentiating various pneumonia pathogens in patient classification (2, 9, 14).

Ground-glass opacities, interstitial changes, consolidation and multiple lobe involvement were frequently found in patients with COVID-19 pneumonia (15). This situation hinders their use as an indicator of disease severity. Likewise, the absence of lesions could not be associated with good evolution, since in the population studied there were practically no patients without pulmonary lesions.

The development of a CT-score was intended to predict objectively and quantitatively the clinical behavior of the patients and specifically the need for oxygen, intensive care or death.

The radiological characteristics of COVID-19 pneumonia were assessed comprehensively by means of a CT-score. The scores of the poor outcome group were significantly higher than those of the favorable outcome group (28 [R: 15-46] vs. 19 [R: 0-41], p= 0.0001).

With the development of a ROC curve and analysis of the variables of evolution according to various cut-off points of the CT-score, three groups of tomographic pulmonary involvement of COVID-19 pneumonia were defined:

a. Mild disease: CT-score: 0-14.
b. Moderate disease: CT-score: 15-21.
c. Severe disease: CT-score: 22.

Patients with mild disease by CT-score had a good evolution in all cases and were detected with a higher sensitivity than that offered by conventional CT evaluation.

In patients with moderate disease by CT-score, a heterogeneous group with high NPV of the need for a reservoir scan as an indicator of chronic disease was determined.

Patients with severe disease by CT-score had a high PPV with respect to the need for the use of oxygen and high sensitivity for the detection of the need for a reservoir mask and unfavorable evolution.

The assessment of CT scans from a CT-CT score was superior to the conventional descriptive report in terms of practicality and accuracy in predicting patient outcome. A simple admission CT score could categorize patients as mild-moderate-severe from the radiological point of view.

The correlation between the CT-score and outcome variables defined as need for oxygen, reservoir scar or poor outcome provides information that can be used in conjunction with clinical parameters in order to decide on earlier and more timely therapeutic approaches.

9. Conclusion

The developed CT-score is a quantitative, simple and extremely useful method in the assessment of patients diagnosed with SARS-CoV-2 infection superior to conventional CT evaluation.

It can be used to characterize tomographic pulmonary involvement into mild, moderate and severe, with a marked correlation with clinical outcome variables. In this way, it can have an important prognostic value and can be used to adapt early and opportune therapeutic conducts in the evolution of the disease.

References

1. Rubin G, Ryerson C, Haramati L, Sverzellati N, Kanne J, Raoof S, et al. The role of chest imaging in patient management during the COVID-19 pandemic: A multinational consensus statement from the Fleischner Society. Radiology. 2020;296:172-80.
2. Simpson S, Kay F, AbbaraA, BhallaS, Chung J, Chung M, et al. Radiological Society of North America Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19. Endorsed by the Society of Thoracic Radiology, the American College of Radiology, and RSNA. Radiology. 2020;2(2).
3. Organización Mundial de la Salud. COVID-19; cronología de la actuación de la OMS [internet]. 2020, 27 de abril [citado: 2021 ene. 10]. Disponible en: https://www.who.int/es/news/item/27-04-2020-who-timeline---covid-19
4. Pan F, Ye T, Sun P, Gui S, Liang B, Li L, et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiology. 2020;200370.
5. .Manli Wang, Ruiyuan Cao, Leike Zhang, Xinglou Yang, Jia Liu, Mingyue Xu; Zhengli Shi, Zhihong Hu, Wu Zhong, Gengfu Xial Remdesivir and chloroquine effectively inhibit the recently emerged novel coronavirus (2019-nCoV) in vitro. Cell Research (2020) 30:269–271; https://doi.org/10.1038/s41422-020-0282-0
6. Ramírez Cotrina CA. La radiología y pandemia COVID-19.Rev Per Radiol. 2020;20:1.
7. Yuan M, Yin W, Tao Z, Tan W, Hu Y. Association of radiologic findings with mortality of patients infected with 2019 novel coronavirus in Wuhan, China. PLoS ONE. 2020;15(3):e0230548. https://doi.org/10.1371/journal.pone.0230548
8. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020.
9. Song F, Shi N, Shan F, Zhang Z, Shen J, et al. Novel coronavirus (2019-nCoV) Pneumonia. Radiology. 2020;295:210-7.
10. Dawei Wang, MD1; Bo Hu, MD1; Chang Hu, MD1; et. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus–Infected Pneumonia in Wuhan, China
11. WHO. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV) [internet]. 2020, enero 30 [citado: 2021 ene, 20]. Disponible en: https://www.Who.Int/news-room/detail/30-01-2020-statement-on-thesecond-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-theoutbreak-of-novel-coronavirus-(2019-ncov).
12. Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, et al. Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection. Radiology. 2020;20:200463.
13. Feng F, Jiang Y, Yuan M, Shen J, Yin H,Geng D, et al. Association of radiologic findings with mortality in patients with avian influenza H7N9 pneumonia. PloS one. 2014.
14. Shi H, Han X,Zheng C. Evolution of CT manifestations in a patient recovered from 2019 novel coronavirus (2019-nCoV) pneumonia in Wuhan, China. Radiology. 2020:200269.
15. Li K, Wu J, Wu F. The clinical and chest CT features associated with severe and critical COVID-19 pneumonia. Invest Radiol. 2020;55(6).

Correspondence

Sebastián Facundo Pérez Espinosa
Avenida del Libertador 7766, piso 11, depto 01 CABA
Buenos Aires, Argentina
sebastian.perez@imat.com.ar
diagnostico.ramosmejia@gmail.com

Received for evaluation: February 10, 2021
Accepted for publication: April 18, 2021