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PROGNOSTIC VALUE OF COMPUTED TOMOGRAPHY AND INFLAMMATORY BIOMARKERS IN HOSPITALIZED PATIENTS WITH COVID-19

VALOR PROGNÓSTICO DA TOMOGRAFIA COMPUTADORIZADA E DE BIOMARCADORES INFLAMATÓRIOS EM PACIENTES HOSPITALIZADOS COM COVID-19

VALOR PRONÓSTICO DE LA TOMOGRAFÍA COMPUTARIZADA Y LOS BIOMARCADORES INFLAMATORIOS EN PACIENTES HOSPITALIZADOS CON COVID-19

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Aryana Isabelle de Almeida Neves Siqueira[1], Edmundo Quintão dos Santos Junior[2], Vinicius Camilo Silva de Alencar[3], Josué de Oliveira Leitão[4], Amanda Cavalcante de Morais[5], Layane Victoria Ananias da Silva[6], Leonardo Martins Aboim Inglês[7], Dárgaro Mauricio Lima Silva[8], Rozangela Maria de Almeida Fernandes Wyszomirska[9]

ABSTRACT

To evaluate the association of thoracic imaging findings, clinical severity, and comorbidities with outcomes in patients with COVID-19, and to determine the discriminatory performance of inflammatory biomarkers and blood gas parameters in predicting these outcomes. A single-center, retrospective, observational study involving 438 hospitalized patients with COVID-19. Associations between imaging findings, clinical severity, comorbidities, and in-hospital death were assessed using Poisson regression, expressed as prevalence ratios (PR) and 95% CIs. The discriminatory performance of inflammatory biomarkers (CRP, LDH, and ferritin) and blood gas parameters (pCO_2 and pO_2) was analyzed using ROC curves. Computed tomography revealed pulmonary involvement in 92.7% of patients; involvement exceeding 75% was independently associated with greater severity (PR=1.67; 95% CI: 1.27–2.18; p<0.001) and showed a borderline association with in-hospital death (PR=1.47; 95% CI: 0.98–2.21; p=0.05). Chest radiography showed low prognostic value. Obesity was the only comorbidity independently associated with greater pulmonary involvement. Among the biomarkers, LDH showed the best performance for predicting death (AUC=0.77), followed by CRP (AUC=0.67). No marker demonstrated significant discriminatory capacity regarding CT findings.Computed tomography showed greater prognostic value than chest radiography for predicting COVID-19 severity. Obesity was independently associated with greater pulmonary involvement, while LDH was the biomarker with the best discriminatory capacity for in-hospital death. The combined use of CT findings and inflammatory biomarkers may contribute to the prognostic stratification of hospitalized patients.

[1] Ph.D. candidate in Nutrition. Universidade Federal de Alagoas (UFAL). E-mail: aryana.siqueira@ebserh.gov.br
[2] Doctor. Universidade Federal de Alagoas (UFAL). E-mail: edmundoquint@gmail.com
[3] Doctor. Universidade Federal de Alagoas (UFAL). E-mail: viniciuscsa4@gamil.com
[4] Doctor. Universidade Federal de Alagoas (UFAL). E-mail: josue.leitão@famed.ufal.br
[5] Doctor. Universidade Federal de Alagoas (UFAL). E-mail: amanda.xcavalcante@gmail.com
[6] Doctor. Universidade Federal de Alagoas (UFAL). E-mail: laiane.silva@famed.ufal.br
[7] Doctor. Universidade Federal de Alagoas (UFAL). E-mail: leonardo.ingles@famed.ufal.br
[8] Doctor. Universidade Federal de Alagoas (UFAL). E-mail: mauricio.dragon@hotmail.com
[9] Doctor of Medicine. Universidade Federal de Alagoas (UFAL).
E-mail: rozangela.wyszomirska@famed.ufal.br

Keywords: COVID-19. Computed Tomography. Biomarkers. Chest Radiography. Comorbidities.

RESUMO
Avaliar a associação entre achados de imagem torácica, gravidade clínica e comorbidades com os desfechos em pacientes com COVID-19, e determinar o desempenho discriminatório de biomarcadores inflamatórios e parâmetros de gasometria na predição desses desfechos. Estudo observacional, retrospectivo e de centro único, envolvendo 438 pacientes hospitalizados com COVID-19. As associações entre achados de imagem, gravidade clínica, comorbidades e óbito hospitalar foram avaliadas por meio de regressão de Poisson, expressas como razões de prevalência (RP) e intervalos de confiança (IC) de 95%. O desempenho discriminatório de biomarcadores inflamatórios (PCR, LDH e ferritina) e parâmetros de gasometria (pCO_2 e pO_2) foi analisado utilizando curvas ROC. A tomografia computadorizada revelou comprometimento pulmonar em 92,7% dos pacientes; o comprometimento superior a 75% associou-se independentemente a maior gravidade (RP = 1,67; IC 95%: 1,27–2,18; p < 0,001) e apresentou associação limítrofe com o óbito hospitalar (RP = 1,47; IC 95%: 0,98–2,21; p = 0,05). A radiografia de tórax apresentou baixo valor prognóstico. A obesidade foi a única comorbidade associada independentemente a maior comprometimento pulmonar. Entre os biomarcadores, a LDH apresentou o melhor desempenho para predição de óbito (AUC = 0,77), seguida pela PCR (AUC = 0,67). Nenhum marcador demonstrou capacidade discriminatória significativa em relação aos achados da TC. A tomografia computadorizada apresentou maior valor prognóstico do que a radiografia de tórax para prever a gravidade da COVID-19. A obesidade associou-se independentemente a maior comprometimento pulmonar, enquanto a LDH foi o biomarcador com melhor capacidade discriminatória para óbito hospitalar. O uso combinado de achados de TC e biomarcadores inflamatórios pode contribuir para a estratificação prognóstica de pacientes hospitalizados.

Palavras-chave: COVID-19. Tomografia Computadorizada. Biomarcadores. Radiografia de Tórax. Comorbidades.

RESUMEN
Evaluar la asociación entre los hallazgos de imagen torácica, la gravedad clínica y las comorbilidades con los desenlaces en pacientes con COVID-19, y determinar la capacidad discriminativa de los biomarcadores inflamatorios y los parámetros de gases en sangre para predecir dichos desenlaces. Estudio observacional, retrospectivo y unicéntrico que incluyó a 438 pacientes hospitalizados con COVID-19. Se evaluaron las asociaciones entre los hallazgos de imagen, la gravedad clínica, las comorbilidades y la mortalidad intrahospitalaria mediante regresión de Poisson, expresadas como razones de prevalencia (RP) e intervalos de confianza (IC) del 95%. La capacidad discriminativa de los biomarcadores inflamatorios (PCR, LDH y ferritina) y de los parámetros de gases en sangre (pCO_2 y pO_2) se analizó mediante curvas ROC. La tomografía computarizada reveló afectación pulmonar en el 92,7% de los pacientes; una afectación superior al 75% se asoció de forma independiente con una mayor gravedad (RP = 1,67; IC del 95%: 1,27–2,18; p < 0,001) y mostró una asociación limítrofe con la mortalidad intrahospitalaria (RP = 1,47; IC del 95%: 0,98–2,21; p = 0,05). La radiografía de tórax mostró un bajo valor pronóstico. La obesidad fue la única comorbilidad asociada de forma independiente a una mayor afectación pulmonar. Entre los biomarcadores, la LDH mostró el mejor rendimiento para predecir la mortalidad (AUC = 0,77), seguida de la PCR (AUC = 0,67). Ningún marcador demostró una capacidad discriminativa

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significativa respecto a los hallazgos de la TC. La tomografía computarizada mostró un mayor valor pronóstico que la radiografía de tórax para predecir la gravedad de la COVID-19. La obesidad se asoció de forma independiente con una mayor afectación pulmonar, mientras que la LDH fue el biomarcador con mejor capacidad discriminativa para la mortalidad intrahospitalaria. El uso combinado de los hallazgos de la TC y los biomarcadores inflamatorios puede contribuir a la estratificación pronóstica de los pacientes hospitalizados.

Palabras clave: COVID-19. Tomografía Computarizada. Biomarcadores. Radiografía de Tórax. Comorbilidades.

1 INTRODUCTION

The COVID-19 pandemic continues to affect global health despite the substantial decline in the number of cases and deaths. In Brazil, according to the Ministry of Health, 8,564 confirmed cases were reported in 2025, representing a 28.8% decrease compared with 2024, while the case fatality rate remained at approximately 2% [1]. However, epidemiological data indicate that COVID-19 still accounts for 53.3% of deaths from Severe Acute Respiratory Syndrome (SARS) caused by respiratory viruses, with an increase in cases in southern Brazil, particularly among older adults, immunocompromised individuals, and people with comorbidities [2].

The respiratory tract is the primary site of SARS-CoV-2 infection, with clinical manifestations ranging from mild illness to pneumonia and hypoxemia, with a risk of progression to SARS and fatal respiratory failure [3-5]. Given its potential severity, it is essential to understand its clinical spectrum and identify prognostic indicators that may guide timely interventions and reduce complications and mortality [6].

In this context, chest X-ray (CXR) and chest computed tomography (CCT) are essential tools for assessing pulmonary involvement in COVID-19. Although CXR is widely available and commonly used for initial assessment, CCT has greater sensitivity for detecting parenchymal abnormalities, including ground-glass opacities and peripheral consolidations; it also allows estimating the extent of pulmonary involvement, which is directly associated with prognosis [7,8].

The main radiographic findings include bilateral ground-glass opacities and peripheral consolidations, whereas CCT offers greater sensitivity and diagnostic accuracy and is considered a first-line imaging modality for the evaluation of patients with COVID-19 [9].

Against this background, the present study aimed to evaluate the prognostic value of chest X-ray, computed tomography, and inflammatory biomarkers in predicting disease severity and in-hospital mortality among patients hospitalized with COVID-19, as well as to investigate the association between comorbidities and the extent of pulmonary involvement.

2 METHODS

2.1 STUDY DESIGN

This retrospective, single-center observational study was based on the analysis of electronic medical records of patients with confirmed COVID-19 who were hospitalized at the Professor Alberto Antunes University Hospital in Maceió, Alagoas, Brazil, a public reference

center for COVID-19 treatment in northeastern Brazil, between April 2020 and September 2022.

2.2 PARTICIPANTS

A total of 448 medical records of patients hospitalized with COVID-19 were identified, of which 438 met the inclusion criteria: age ≥18 years, both sexes, and a positive SARS-CoV-2 result from nasopharyngeal and oropharyngeal swab samples detected by RT-PCR. Patients whose medical records contained incomplete data were excluded.

2.3 PROCEDURES AND VARIABLES

Data were manually extracted by four previously trained researchers and subsequently checked by two independent reviewers, ensuring anonymization and confidentiality. Discrepancies were resolved by consensus through review of the electronic medical records. Medical terminology was standardized, and the results were coded to ensure data consistency.

Clinical variables (disease severity, comorbidities, and in-hospital outcome), laboratory variables (hemoglobin, leukocytes, C-reactive protein [CRP], lactate dehydrogenase [LDH], ferritin, creatinine, and blood glucose), arterial blood gas parameters (pO_2 and pCO_2), and imaging examinations (chest X-ray and chest computed tomography) were analyzed. Disease severity was adapted from the World Health Organization classification (10) as follows: 0 – non-severe (moderate disease); 1 – severe; 2 – critical.

The comorbidities identified in the medical records included hypertension, diabetes mellitus, obesity, heart disease, lung disease, among others. The clinical outcome was categorized as hospital discharge or death.

Chest radiographs were obtained using fixed or portable digital X-ray systems in posteroanterior (PA) or anteroposterior (AP) projections, preferably within the first 24 hours of hospitalization. Reports were issued by on-call radiologists and reviewed by a second specialist; any discrepancies were resolved by a third evaluator, the coordinator of the radiology service. Classification followed the Fleischner Society consensus [7]: 0 = normal; 1 = diffuse opacity; 2 = consolidation.

CCTs were performed using volumetric chest acquisition with thin-section images (1.0-1.25 mm), without contrast, and were classified according to the degree of pulmonary

involvement using the severity score proposed by Wong et al. [11]: 0 = no involvement; 1 = <25%; 2 = 25-50%; 3 = 50-75%; 4 = >75%.

2.4 DATA ANALYSIS

Data were entered into Microsoft Excel® and analyzed using Jamovi software (version 2.3; https://www.jamovi.org), with a significance level of 5% ($p<0.05$). Categorical variables were expressed as absolute and relative frequencies, and continuous variables as mean ± standard deviation. Associations were assessed using the chi-square test and analysis of variance (ANOVA), and prevalence ratios (PRs) were estimated using Poisson regression, considering disease severity, comorbidities, clinical outcome, and imaging findings.

Receiver operating characteristic (ROC) curves were constructed using MedCalc® software to assess the discriminative performance of the variables. The areas under the curve (AUCs), their respective 95% confidence intervals, sensitivity, specificity, and Youden index were calculated to determine the optimal cutoff point. The ROC curves were graphically represented.

2.5 ETHICAL ASPECTS

The study was registered on Plataforma Brasil under No. 31116320.3.0000.5013 and approved by the institution's Research Ethics Committee, under Opinion No. 4.297.975.

3 RESULTS

The demographic, clinical, and radiological characteristics of the study population are presented in Table 1. A total of 438 hospitalized patients with a confirmed diagnosis of COVID-19 were included, with a mean age of 54.9 ± 18.0 years and a predominance of males (53.2%). Most patients had severe or critical forms of the disease (65.8%), and in-hospital mortality was 43.6%. The most frequent comorbidities were hypertension (42.9%) and diabetes mellitus (32.8%). Among patients who underwent imaging examinations, chest X-ray showed a predominance of diffuse opacities (65.9%). On computed tomography, 92.7% of patients showed pulmonary involvement, and 46.0% of those who underwent CCT had involvement of more than 50% of the lung parenchyma.

Table 1

Demographic and clinical characteristics and imaging findings of the study population

Variable	Result
Demographic characteristics:	
Age (years), mean ± SD (n= 438)	54.9 ± 18.0
Male	233 (53.2%)
Female	205 (46.8%)
Disease severity (n= 438):	
Non severe	150 (34.2%)
Severe	129 (29.5%)
Critical	159 (36.3%)
Comorbidities (n=427):	
Hypertension	183 (42.9%)
Diabetes	140 (32.8%)
Immunodepression/neoplasm	93 (21.7%)
Obesity	48 (11.2%)
Tobacco use	39 (9.1%)
Pneumopathies	33 (7.7%)
Cardiopathies	24 (5.6%)
Chest X-ray (n=126):	
No abnormalities	23 (18.3%)
Diffuse opacities	83 (65.9%)
Consolidations	20 (15.9%)
Computed tomography (n=300):	
No abnormalities	22 (7.3%)
<25%	46 (15.3%)
25-50%	94 (31.3%)
50-75%	89 (29.7%)
>75%	49 (16.3%)
Clinical outcome (n=427):	
Discharge	241 (56.4%)
Death	186 (43.6%)

Source: Authors

The results of the laboratory and arterial blood gas tests of the study population are shown in Table 2. Laboratory tests showed a profile consistent with a systemic inflammatory

response, characterized by leukocytosis and elevated C-reactive protein, lactate dehydrogenase, and ferritin with a systemic inflammatory response characterized by leukocytosis (12,182 ± 10,558 cells/μL) and elevated inflammatory biomarkers, including C-reactive protein (131.7 ± 98.8 mg/L), lactate dehydrogenase (474.6 ± 436.8 U/L), and ferritin (1,919 ± 2,382 ng/mL). Among the arterial blood gas parameters, mean pCO_2 was 44.9 ± 21.9 mmHg and mean pO_2 was 94.7 ± 52.1 mmHg.

Table 2

Laboratory and arterial blood gas characteristics of the study population

Variable	Mean ± SD
Hemoglobin (g/dL) (n= 420)	12.35 ± 2.96
Leucocytes (/μL) (n=418)	12.182 ± 10.558
CRP (mg/L) (n= 396)	131.7 ± 98.8
LDH (U/L) (n=245)	474.6 ± 436.8
Ferritin (ng/mL) (n=304)	1.919 ± 2.382
Creatinine (mg/dL) (n=413)	1.44 ± 1.75
Blood glucose (mg/dL) (n=184)	187.6 ± 140.3
pCO_2 (mmHg) (n=168)	44.9 ± 21.9
pO_2 (mmHg) (n=166)	94.7 ± 52.1

* CRP: C-reactive protein; LDH: lactate dehydrogenase; pCO_2: partial pressure of carbon dioxide; pO_2: partial pressure of oxygen.
Source: Authors

3.1 ASSOCIATION BETWEEN IMAGING FINDINGS, COMORBIDITIES, AND CLINICAL OUTCOMES

The results of the adjusted Poisson regression are presented in Table 3. Abnormalities identified on chest X-ray were not significantly associated with COVID-19 severity or in-hospital mortality, although the prevalence ratios remained above 1, suggesting a trend toward increased risk. These findings indicate limited prognostic performance of conventional chest X-ray when used alone for risk stratification.

Table 3

Association between radiological findings, comorbidities, and clinical outcomes in patients hospitalized with COVID-19

Variable	Crude PR (95% CI)	p-value	Adjusted PR (95% CI)	p-value
CXR × severity/death				
Diffuse opacities – Severity	1.08 (0.79–1.48)	0.59	1.06 (0.77–1.45)	0.71
Consolidations – Severity	1.23 (0.86–1.77)	0.25	1.18 (0.82–1.70)	0.35
Diffuse opacities – Death	1.56 (0.87–2.80)	0.13	1.38 (0.77–2.46)	0.27
Consolidations – Death	1.65 (0.85–3.18)	0.13	1.56 (0.81–2.98)	0.17
CCT × severity/death				
Involvement 50-75% - Severity	1.17 (0.89-1.55)	0.24	1.14 (0.86-1.51)	0.33
Involvement >75% - Severity	1.75 (1.34-2.29)	<0.001	1.67 (1.27-2.18)	<0.001
Involvement 50-75% - Death	1.22 (0.80-1.85)	0.34	1.10 (0.75-1.63)	0.6
Involvement >75% - Death	1.64 (1.07-2.50)	0.02	1.47 (0.98-2.21)	0.05
Comorbidities and clinical outcomes				
Hypertension - CXR	1.16 (0.95-1.41)	0.14	1.13 (0.93-1.39)	0.2
Hypertension - CCT	1.14 (1.02-1.27)	0.01	1.09 (0.97-1.23)	0.11
Diabetes mellitus - CXR	0.90 (0.74-1.10)	0.34	0.84 (0.69-1.03)	0.09
Diabetes mellitus - CCT	1.05 (0.93-1.18)	0.37	1.00 (0.88-1.14)	0.9
Pneumopathies - CXR	0.90 (0.61-1.32)	0.59	0.87 (0.60-1.25)	0.45
Pneumopathies - CCT	1.01 (0.79-1.31)	0.89	1.04 (0.81-1.33)	0.73
Obesity - CXR	1.32 (1.02-1.71)	0.02	1.33 (1.03-1.72)	0.02
Obesity - CCT	1.15 (0.99-1.32)	0.05	1.16 (1.01-1.33)	0.03
Cardiomyopathies - CXR	0.88 (0.68-1.14)	0.36	0.84 (0.65-1.08)	0.18
Cardiomyopathies - CCT	1.00 (0.76-1.33)	0.94	0.96 (0.74-1.26)	0.8

* PRs adjusted for sex and age. In the chest X-ray analyses, the reference category was “no abnormalities”; in the CCT analyses, the reference category was 25-50% pulmonary involvement.
PR: prevalence ratio; CXR: chest X-ray; CCT: chest computed tomography.
Source: Authors

In contrast, computed tomography showed superior prognostic performance. Pulmonary involvement of 50-75% was not significantly associated with disease severity or in-hospital mortality. However, patients with more than 75% pulmonary involvement were more likely to progress to severe forms of COVID-19 (PR = 1.67; 95% CI: 1.27-2.18; p < 0.001), while the association with in-hospital mortality remained borderline after adjustment for sex and age (PR = 1.47; 95% CI: 0.98-2.21; p = 0.05).

Among the comorbidities evaluated, only obesity remained independently associated with the presence of pulmonary abnormalities on both chest X-ray (PR = 1.33; 95% CI: 1.03-

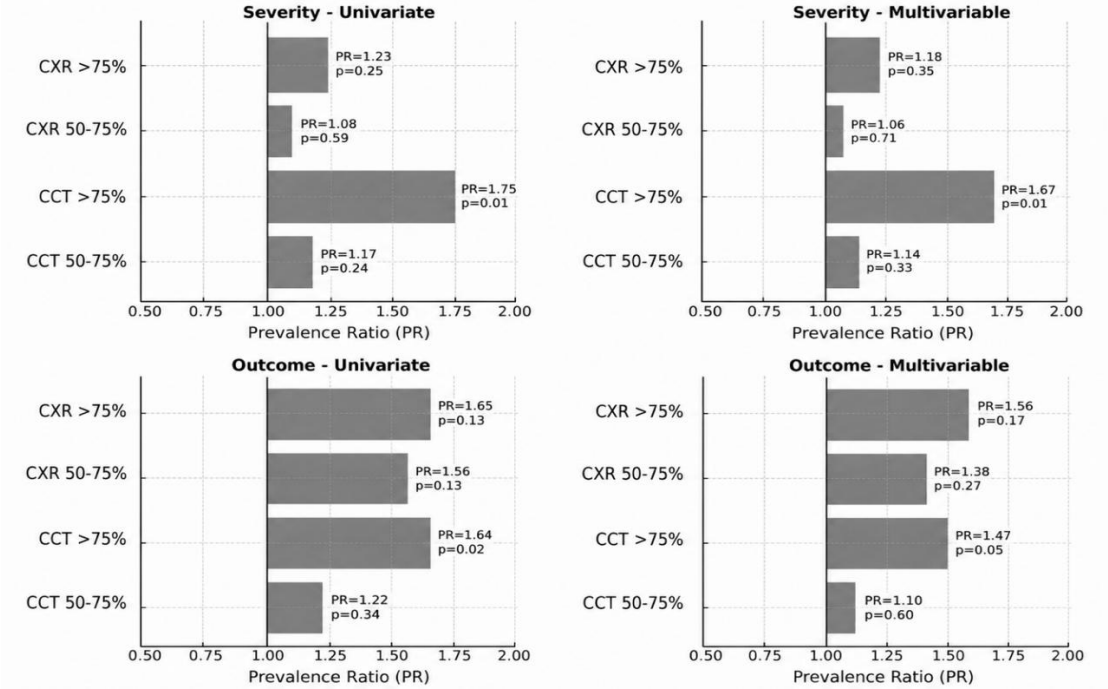
1.72; p = 0.02) and computed tomography (PR = 1.16; 95% CI: 1.01-1.33; p = 0.03). The other comorbidities were not significantly associated after adjustment for sex and age.

PROGNOSTIC COMPARISON BETWEEN CXR AND CCT

The comparison between imaging methods revealed important differences in prognostic performance (Figure 1). While chest X-ray was not significantly associated with disease severity or in-hospital mortality, computed tomography evidenced greater risk-stratification capability.

Figure 1

Comparison of the prognostic performance of chest X-ray (CXR) and chest computed tomography (CCT) in predicting disease severity and in-hospital mortality in patients with COVID-19.



Source: Data extracted from Jamovi (2025), adapted by the authors.

Patients with pulmonary involvement greater than 75% were more likely to progress to severe forms of COVID-19. With regard to in-hospital mortality, a borderline association was observed after adjustment for sex and age (PR = 1.47; 95% CI: 0.98-2.21; p = 0.05).

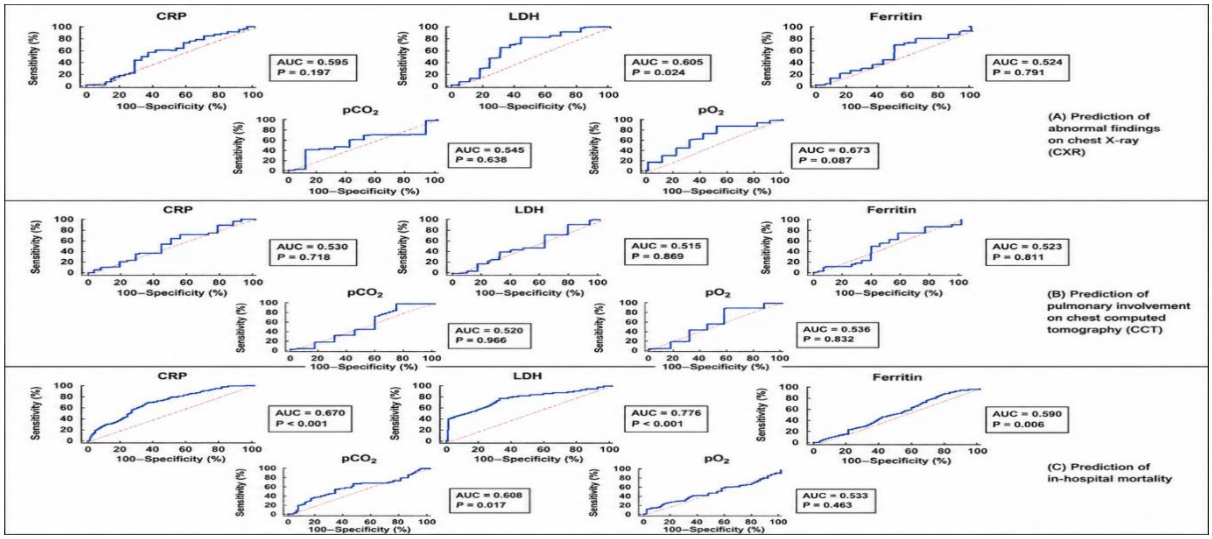
PREDICTIVE PERFORMANCE OF BIOMARKERS

Figure 2 presents the ROC curves of inflammatory biomarkers and arterial blood gas parameters for predicting abnormalities on chest X-ray (Panel A), computed tomography (Panel B), and in-hospital mortality (Panel C). For chest X-ray, LDH showed the best

discriminative performance (AUC = 0.69; 95% CI: 0.56-0.80; p = 0.02), whereas CRP, ferritin, and arterial blood gas parameters showed low discriminative power. For computed tomography, none of the variables evidenced relevant discriminatory ability, with AUC values ranging from 0.50 to 0.53. In contrast, for predicting in-hospital mortality, LDH showed the highest accuracy (AUC = 0.77; 95% CI: 0.72-0.82; p < 0.001), followed by CRP (AUC = 0.67; 95% CI: 0.62-0.71; p < 0.001), whereas ferritin and pCO_2 showed modest performance and pO_2 showed no discriminatory ability. These findings indicate that the biomarkers evaluated have greater prognostic utility for mortality than for predicting structural pulmonary abnormalities.

Figure 2

ROC curves of inflammatory biomarkers and blood gas parameters for predicting chest X-ray (CXR) abnormalities (Panel A), pulmonary involvement on chest computed tomography (CCT) (Panel B), and in-hospital mortality (Panel C).



Source: Data extracted from MedCalc (2025), adapted by the authors.

4 DISCUSSION

The present study evaluated 438 patients hospitalized with COVID-19, of whom 53.2% were men and 46.8% were women. Most patients presented with severe (32.4%) or critical (31.9%) forms of the disease, according to the World Health Organization classification [10], findings consistent with those reported by Zhou et al. [12] and Terwangne et al. [13]. Overall mortality was 43.6% (186 patients), with no relevant difference between sexes (36.2% among men and 40.9% among women). The high mortality rate reflects the clinical profile of the

sample, characterized by a high prevalence of comorbidities associated with greater disease severity and poorer outcomes, as described by Guan et al. [14].

In the analysis of chest X-ray (CXR) findings, 65.9% of patients showed diffuse opacities and 15.9% had consolidations, whereas 18.2% showed no significant abnormalities. Regression analysis revealed no statistically significant association between radiographic findings and disease severity or in-hospital mortality, although the prevalence ratios (PRs) remained above 1. Although the PRs remained above 1, the confidence intervals included the reference value, limiting the interpretation of an independent association.

These findings may reflect the lower sensitivity of conventional chest X-ray for quantifying the extent of pulmonary involvement, the relatively small number of patients who underwent the examination (n = 126), or the heterogeneity of radiographic abnormalities, corroborating the evidence reported by Borakati et al. [15], Mogami et al. [16], and Pettenuzzo et al. [17]. Nevertheless, CXR remains useful as an initial screening method, particularly in resource-limited settings, and should be complemented by computed tomography.

Among the 300 patients who underwent CCT, 92.7% showed findings consistent with COVID-19, whereas only 7.3% had no typical abnormalities. Pulmonary involvement of 50-75% was observed in 29.7% of patients, while 16.3% had involvement greater than 75%, with a significantly higher risk of progression to more severe disease (PR = 1.75; 95% CI: 1.34-2.29; $p < 0.01$). This association remained significant after multivariate adjustment (PR = 1.67; 95% CI: 1.27-2.18; $p < 0.01$). According to Carvalho et al. [18], these degrees of pulmonary involvement are associated with longer hospital stays, greater need for ventilatory support, and higher mortality.

An association was also observed between pulmonary involvement greater than 75% on CCT and an unfavorable clinical outcome (PR = 1.64; $p = 0.02$ in the univariate analysis and PR = 1.47; $p = 0.05$ in the adjusted multivariate analysis). These findings reinforce the role of CCT as a robust prognostic tool in COVID-19, with greater capacity than chest X-ray to quantify pulmonary involvement and estimate disease severity and clinical outcomes. They are consistent with the findings of Francone et al. [19], Abdel-Tawab et al. [20], and Fillippenko et al. [21], who identified pulmonary involvement ≥75% as a direct predictor of unfavorable outcomes and the need for intensive care unit (ICU) admission, as well as with the systematic reviews by Zakariaee et al. [22] and Majrashi et al. [23].

When comparing the two imaging methods (CXR and CCT), computed tomography clearly exhibited superior prognostic performance (Figure 1), with pulmonary involvement

>75% associated with greater disease severity and mortality, supporting its use for risk stratification in COVID-19.

Among the comorbidities evaluated, only obesity remained independently associated with greater pulmonary involvement, as described by Zhang et al. [24]. In a systematic review, Nigatu et al. [25] concluded that the presence of comorbidities increased the likelihood of more severe COVID-19.

A relevant finding was the independent association between obesity and presence of pulmonary abnormalities on both CXR ($p < 0.02$) and CCT ($p < 0.03$). These findings highlight obesity as a factor that modulates systemic inflammation and pulmonary vulnerability to SARS-CoV-2, as described by Simonnet et al. (26).

Adipose tissue acts as a viral reservoir and secretes proinflammatory cytokines (IL-6 and TNF-α) that amplify the dysregulated immune response, contributing to the hyperinflammatory state characteristic of severe forms of COVID-19 [27,28]. Additional evidence suggests that obesity may lead to earlier onset of severe disease in younger patients, possibly due to increased ACE2 expression and associated endothelial dysfunction, as reported by Kass et al. [29].

Hypertension was significantly associated with disease severity in the univariate analysis (PR = 1.14; 95% CI: 1.02-1.27; $p < 0.01$), but this association lost significance after multivariate adjustment, possibly mediated by age and obesity. Hanif et al. [30] reported similar findings, indicating that hypertension is more strongly associated with mortality than with the extent of pulmonary injury. Other comorbidities – diabetes mellitus, chronic lung diseases, and cardiomyopathies – were not significantly associated, which may reflect individual variability in the inflammatory response or limitations in the sensitivity of imaging methods.

Lactate dehydrogenase (LDH) was the biomarker that showed the most consistent performance in this study, standing out both in predicting chest X-ray abnormalities and, particularly, in discriminating in-hospital mortality, for which it achieved the largest area under the curve among all markers evaluated (AUC = 0.77). This finding reinforces the potential of LDH as a prognostic marker of COVID-19 severity.

Lactate dehydrogenase (LDH) is a cytoplasmic enzyme found in most tissues and released into the circulation following cell membrane damage. It is recognized as an indirect marker of tissue injury, hypoxia, and necrosis. In COVID-19, elevated LDH levels reflect the extent of alveolar injury and the systemic inflammatory response and are associated with acute respiratory distress syndrome, multiple organ dysfunction, and poorer clinical

prognosis. These pathophysiological mechanisms help explain the high discriminative performance observed for LDH in this study.

Our results are consistent with those of Henry et al. [31], who showed good sensitivity of LDH for predicting radiographic abnormalities in patients with COVID-19, and with the findings of Zhang et al. [32], who identified this biomarker as useful for assessing disease severity and monitoring treatment response. In addition, systematic reviews and meta-analyses have consistently shown an association between elevated LDH levels and a higher risk of intensive care unit admission, need for mechanical ventilation, and in-hospital mortality [33].

Among the main strengths of this study are the robustness of the sample, comprising 438 patients, and the extended inclusion period spanning different phases of the pandemic, which increased statistical power and allowed the capture of distinct clinical and epidemiological dynamics. The integrated assessment of imaging examinations and laboratory biomarkers in relation to relevant clinical outcomes provided a comprehensive analysis of patient progression, thereby enhancing the clinical relevance of the findings.

Additionally, conducting the study in a real-world hospital setting reinforces its practical applicability and external validity. However, several limitations should be considered, including the retrospective, single-center design; potential information bias resulting from the use of medical records; the lack of serial measurements of the biomarkers evaluated; and the lack of multivariate adjustment for potential confounders such as viral variants, vaccination status, and therapeutic strategies. Finally, not all patients underwent chest X-ray, computed tomography, and laboratory testing, resulting in different sample sizes across the analyses.

5 CONCLUSION

The present study evidenced that prognostic stratification of patients hospitalized with COVID-19 benefits from rigorous, combined criteria, showing that imaging methods and biomarkers play distinct yet complementary roles in predicting disease severity and in-hospital mortality.

Chest computed tomography showed superior prognostic performance compared with conventional chest X-ray. Pulmonary parenchymal involvement greater than 75% on CCT emerged as an independent predictor of clinical severity and unfavorable outcomes, being associated with a higher risk of progression to critical forms of the disease and death, even

after adjustment for confounding factors such as sex and age. In addition, obesity emerged as the only comorbidity directly associated with a greater extent of tissue injury on both imaging modalities, underscoring its role as a modulator of pulmonary vulnerability.

Among the biomarkers evaluated, LDH showed the best discriminative performance for in-hospital mortality, followed by CRP. The findings indicate that computed tomography has greater prognostic capability for estimating COVID-19 severity, whereas LDH showed greater discriminative ability for in-hospital mortality.

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