Original Article

Cardiovascular Complications in Patients with COVID-19 and Their Relationship with Mortality: An Echocardiographic Perspective

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Abstract

Background: **Echocardiography plays a fundamental role in the diagnosis of cardiovascular diseases related to SARS-CoV-2 infection. Despite prior investigation in the literature, studies focusing on cardiovascular manifestations among patients from the Brazilian Legal Amazon region remain scarce.**

Objectives: **To identify cardiovascular complications of COVID-19 in patients admitted to a hospital in the North Region of Brazil and their potential association with mortality.**

Methods: **We conducted a retrospective cohort study including 25 medical records of adults diagnosed with COVID-19. These patients were admitted to a hospital in Belém, Pará, in Northern Brazil, between March 2020 and December 2020. Demographic and clinical characteristics, as well as echocardiographic findings, were extracted from the medical records. Statistical analyses were performed adopting a significance level of $\alpha < 0.05$. The project was approved by the Research Ethics Committee (approval number: 5.540.025).**

Results: **Among the 25 patients, 15 (60%) were male, with a mean age of 69.6 ± 14.4 years. Hypertension (n = 23; 92%) was the most prevalent cardiovascular risk factor, followed by diabetes (n = 11; 44%) and obesity (n = 8; 32%). We detected echocardiographic abnormalities in 20 (80%) individuals, with diastolic dysfunction being the most frequent (n = 18; 72%). All 7 patients who died showed abnormal echocardiography ($p > 0.05$). Atrial fibrillation or flutter (n = 5; 20%), decompensated heart failure (n = 3; 12%), and cardiogenic shock (n = 2; 8%) were the most common types of cardiovascular involvement.**

Conclusions: **An increasing trend in COVID-19 mortality was observed among patients with cardiovascular complications. Nevertheless, the statistical power was limited by the small sample size.**

Keywords: **Cardiovascular Diseases; Echocardiography; COVID-19; Mortality.**

Palavras-chave: **Doenças Cardiovasculares; Ecocardiografia; COVID-19; Mortalidade.**

Introduction

SARS-CoV-2 was first reported in Wuhan, China, in December 2019. The virus subsequently spread around the world, leading to the COVID-19 pandemic, which was officially declared in March 11, 2020.1

The COVID-19 pandemic became one of the greatest health crises in modern history. By 2022, the World Health Organization confirmed 526,182,662 cases and 6,286,057 deaths, underscoring the serious consequences of the disease worldwide.[2] In this scenario, Brazil ranked as the country with the third highest number of cases (30,846,602) and the second highest number of deaths (666,037). Initially, the North Region of Brazil recorded high infection and mortality rates, although it was later considered the region with the lowest number of cases and deaths in the country.[3]

A study conducted in China estimated a COVID-19 case fatality rate of 2.3%, reaching as high as 10.5% in patients with cardiovascular comorbidities.[4] Beyond respiratory symptoms, infection with SARS-CoV-2 has been associated with a range of cardiovascular complications, including acute myocardial injury, cardiac arrhythmias, myocarditis, and venous thromboembolism.[5]

Echocardiography has played a central role in the diagnosis of cardiovascular complications in patients with

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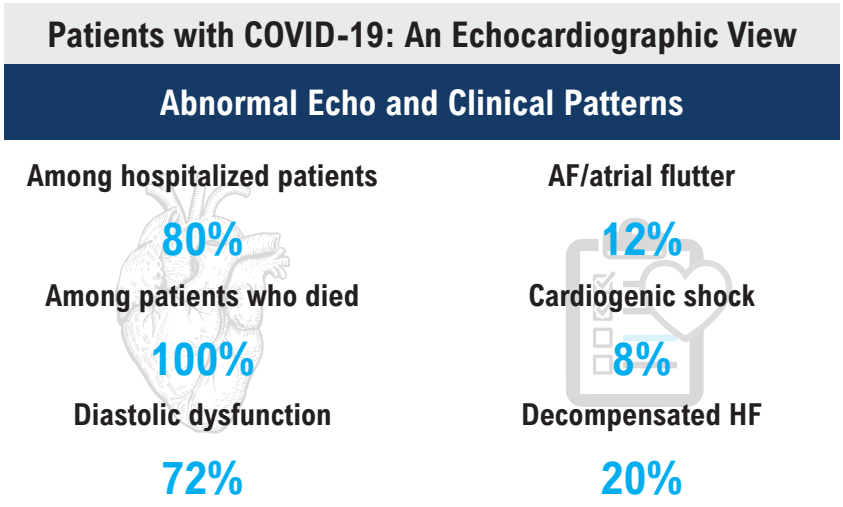
Central Illustration: Cardiovascular Complications in Patients with COVID-19 and Their Relationship with Mortality: An Echocardiographic Perspective



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AF: atrial fibrillation; Echo: echocardiogram; HF: heart failure.

COVID-19.[6] During the disease outbreak, echocardiography proved to be an important imaging method, due to its greater portability compared to other imaging modalities, allowing for bedside assessment, especially in critically ill or isolated patients.[6]

While the cardiovascular complications of SARS-CoV-2 infection have already been widely explored by several international scientific studies, there is a significant lack of data from the North Region of Brazil. Accordingly, this study aimed to identify cardiovascular abnormalities among individuals with COVID-19 admitted to a hospital in the Brazilian Legal Amazon, and to assess their relationship with disease-related mortality.

Methods

Ethical considerations

The research team strictly followed Resolution 466/2012, issued by the Brazilian National Health Council. Accordingly, the study received ethical approval from the Research Ethics Committee on Human Beings of the Evandro Chagas Institute (approval number 5.540.025, July 22, 2022).

No direct contact with subjects took place during this retrospective study, which only used anonymized data extracted from medical records. For this reason, the Research Ethics Committee granted a waiver of informed consent.

We committed to using the data exclusively for the study's purposes, maintaining confidentiality and privacy as required by Resolution 466/2012.

Study characterization

This observational epidemiological study adopted a longitudinal and retrospective design to investigate cardiovascular complications associated with COVID-19 in hospitalized patients who underwent transthoracic Doppler echocardiography.

This research report was prepared in accordance with the STROBE recommendations.

Study setting and population

We conducted the research at Hospital Guadalupe, located in the city of Belém, Pará, in the North Region of Brazil. Data were collected from medical records of patients admitted to this facility between March 2020 and December 2020.

Inclusion and exclusion criteria

This research included adults of both sexes, aged 18 years or older, diagnosed with SARS-CoV-2 pulmonary infection, who underwent transthoracic Doppler echocardiography during their hospital stay. Records lacking sufficient data for analysis were excluded.

COVID-19 diagnosis

Participants were tested for SARS-CoV-2 using real-time reverse transcription polymerase chain reaction (RT-PCR), the preferred method for diagnosing COVID-19.

Nevertheless, when RT-PCR results were not recorded, we adopted the Operational Definitions of the Brazilian Ministry of Health (2021) for confirming positive cases.[8]

Cardiovascular involvement

The clinical presentations of COVID-19–related cardiovascular involvement were cardiogenic shock, decompensated heart failure, myocarditis, pericarditis, and cardiac arrhythmias.

Echocardiographic findings

The main echocardiographic findings were identified through exams performed with a CX50 portable ultrasound device (Philips Medical Systems), which was widely employed in similar investigations.

The echocardiographic measurements followed the recommendations of the American Society of Echocardiography and the European Association of Cardiovascular Imaging.[8,9] The median number of days between hospital admission and examination was 6 days.

Data collection

The following variables were collected: previous medical history, cardiovascular risk factors, pre-existing cardiovascular diseases prior to SARS-CoV-2 infection, echocardiographic signs of cardiovascular complications, and clinical outcomes.

As some of the selected medical records lacked electrocardiogram (ECG) results, the identification of cardiac arrhythmias occasionally relied on descriptive diagnoses, without direct interpretation of ECG tracings.

Data analysis

The dataset was organized in a Microsoft Excel spreadsheet. Subsequently, the sample was characterized based on the absolute and relative frequencies of its epidemiological and clinical variables. Continuous variables were expressed as mean ± standard deviation.

We applied Fisher's exact test to explore possible associations among cardiovascular complications, echocardiographic findings, and clinical outcomes. In addition, we performed a statistical analysis using Bioestat software (version 5.3), with a α value < 0.05 considered statistically significant.

Results

We initially analyzed 284 echocardiograms. After removing outpatient procedures, 192 records remained. Among the inpatients, only 25 had a confirmed COVID-19 diagnosis, thus comprising the final study sample.

Data were collected from the medical records of these 25 patients who were hospitalized with COVID-19 and underwent echocardiography during their hospital stay. The most relevant data are summarized in the Central Illustration.

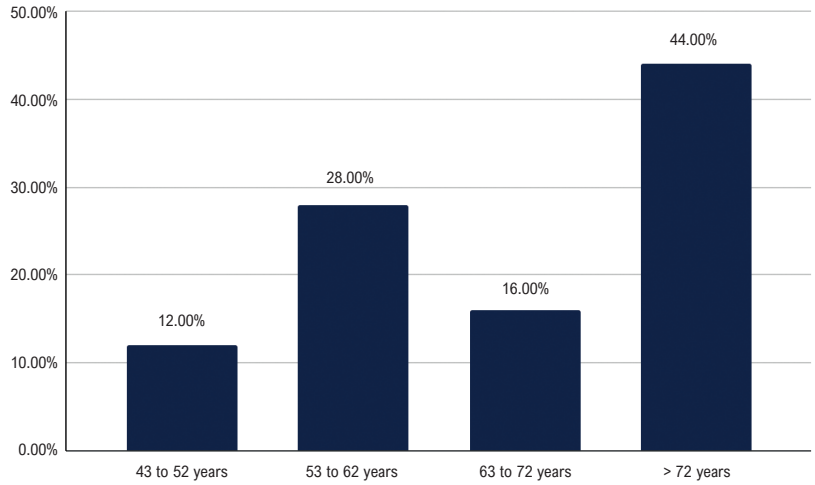
Among the 25 medical records evaluated, 60% (15/25) were from male patients, and 40% (10/25) were female. The mean age of the patients was 69.6 ± 14.4 years. Figure 1 presents the age distribution of study participants.

The cardiovascular risk factors identified at the time of hospital admission are shown in Table 1.

Table 2 details the forms of cardiovascular involvement according to their echocardiographic abnormalities and clinical manifestations, as well as their association with the mortality rate.

Figure 2 illustrates outcomes related to the number of deaths and hospital discharges of the patients.

Table 3 displays clinical presentations of cardiovascular involvement, exploring their link with the echocardiographic findings.



Source: Research protocol..

Figure 1 – *Age distribution of the study population hospitalized at Hospital Guadalupe, Belém, Pará, Brazil, between March 2020 and December 2020.*

Table 1 – Cardiovascular risk factors identified in patients hospitalized with COVID-19 at Hospital Guadalupe, in Belém, Pará, Brazil, between March 2020 and December 2020.

Cardiovascular risk factors	N = 25	%
Systemic arterial hypertension	23	92.0
Diabetes mellitus	11	44.0
Obesity	8	32.0
Coronary artery disease	7	28.0
Cardiac arrhythmias	4	16.0
Previous smoking	3	12.0
Heart failure	1	4.0
Alzheimer's disease	1	4.0
Asthma	1	4.0
COPD, pulmonary fibrosis	1	4.0
Chronic kidney disease	1	4.0

Source: Research protocol. COPD: chronic obstructive pulmonary disease. %: Frequency; N: Records analyzed.

Table 2 – Clinical and echocardiographic alterations and their association with the mortality rate of patients hospitalized with COVID-19 at Hospital Guadalupe, in Belém, Pará, Brazil, between March 2020 and December 2020.

Cardiovascular involvement	Discharge (n = 18)	%	Death (n = 7)	%	Total (n = 25)	%	p value
Abnormal echocardiogram							
Yes	13	72.2	7	100.0	20	80.0	0.2743
No	5	27.8	–	–	5	20.0	
AF/atrial flutter							
Yes	2	11.1	3	42.9	5	20.0	0.113
No	16	88.9	4	57.1	20	80.0	
Decompensated HF							
Yes	1	5.6	2	28.6	3	12.0	0.1796
No	17	94.4	5	71.4	22	80.0	
Cardiogenic shock							
Yes	–	–	2	28.6	2	8.0	0.07
No	18	100.0	5	71.4	23	92.0	

*Source: Research protocol. Dashes (–) indicate a value of zero, not resulting from rounding. AF: atrial fibrillation; HF: heart failure. %: Frequency; N: Records analyzed. * Fisher's exact test.*

Lastly, the association between echocardiographic abnormalities and clinical outcomes is displayed in Table 4, offering insights into their prognostic value.

Discussion

Statistical analysis of data from the medical records allowed the characterization of the clinical and epidemiological profile of the patients diagnosed with COVID-19 who underwent echocardiography during hospitalization.

Among the selected patients, 60% were male, and 40% were female, with a mean age of 69.6 ± 14.4 years. The predominance of male patients (71.4%) among the deaths recorded is in agreement with findings from a similar study,[10] suggesting male sex as a possible marker of mortality.

Overall, 92% of study participants had a prior diagnosis of systemic arterial hypertension, 44% showed type 2 diabetes mellitus, and 32% were obese. Notably, the proportion of hypertensive patients was considerably higher than in other investigations, which ranged from 57% to 69%.[11-14] We believe this

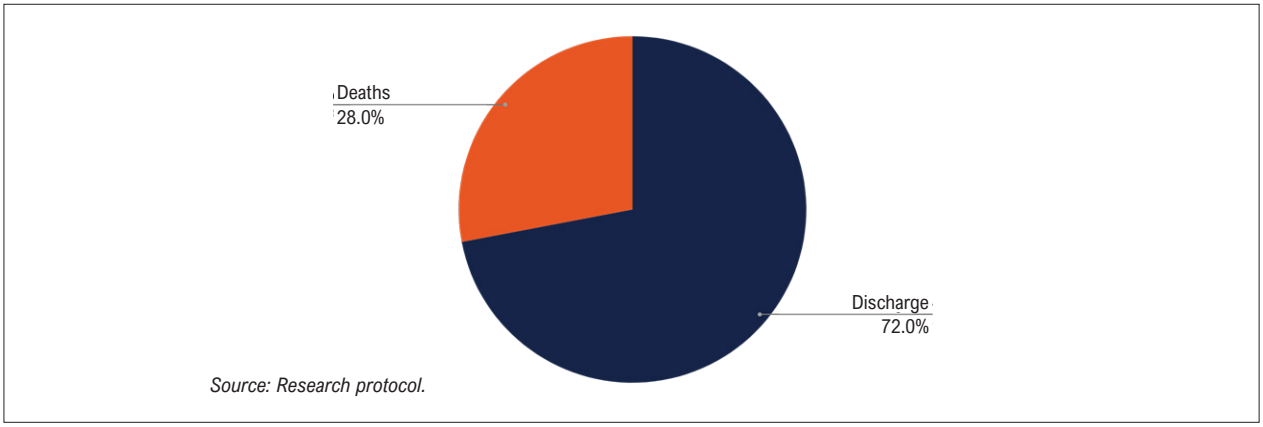


Figure 2 – *Outcomes related to the number of deaths and hospital discharges of patients hospitalized with COVID-19 at Hospital Guadalupe in Belém, Pará, Brazil, between March 2020 and December 2020.*

Table 3 – Cardiovascular involvement and its association with echocardiographic findings in patients hospitalized with COVID-19 at Hospital Guadalupe in Belém, Pará, Brazil, between March 2020 and December 2020.

Cardiovascular involvement	Normal (n = 5)	%	Abnormal (n = 20)	%	Total (n = 25)	%	p value
AF/Atrial flutter							
Yes	–	–	5	25.0	5	20.0	0.544
No	5	100.0	15	75.0	20	80.0	
Decompensated HF							
Yes	–	–	3	15.0	3	12.0	0.587
No	5	100.0	17	85.0	22	88.0	
Cardiogenic shock							
Yes	–	–	2	10.0	2	8.0	1.0
No	5	100.0	18	90.0	23	92.0	

*Source: Research protocol. Dashes (–) indicate a value of zero, not resulting from rounding. AF: atrial fibrillation; HF: heart failure. %: Frequency; N: Records analyzed. * Fisher's exact test.*

may be explained by the higher prevalence of the disease in Belém than in the settings where the referenced studies were performed.

Regarding the cardiovascular abnormalities detected by echocardiography, 80% of the exams revealed alterations. Among them, the main finding was diastolic dysfunction, present in 72% of the participants. This frequency was higher than that reported in a more statistically robust study, in which only 16% of individuals exhibited dysfunction.[11] Conversely, this discrepancy may plausibly be attributed to the higher burden of comorbidities in the current sample, especially hypertension and diabetes.

None of the patients without echocardiographic alterations presented atrial fibrillation, atrial flutter, heart failure, or cardiogenic shock. On the other hand, among individuals with echocardiographic abnormalities, these conditions were diagnosed in 25%, 15%, and 10% of cases, respectively ($p > 0.05$). Although cardiovascular complications were only observed in the group with echocardiographic findings, it was not possible to infer a statistically significant association ($p > 0.05$).

The observed mortality rate was 28%, a value higher than the 20% and 15% reported in similar studies,[15,16] but lower than the 32% and 38% found in other investigations,[14,17] possibly reflecting differences in the severity criteria adopted.

All deaths (100%) occurred in patients with echocardiographic abnormalities, indicating a trend whose validity is limited by the small sample size.

Pericardial effusion has been described as one of the most common pathological findings in SARS-CoV-2 infection, resulting from pericarditis. Interestingly, no cases of pericardial effusion were identified among the study participants, differing from the 30% reported in a similar study.[18] This discrepancy is likely due to the greater severity of that study's sample.

Table 4 – Echocardiographic abnormalities and their association with the outcomes of patients hospitalized for COVID-19 at Hospital Guadalupe, in Belém, Pará, Brazil, between March 2020 and December 2020.

Abnormalities	Discharge n = 18	%	Death n = 7	%	Total n = 25	%	p value
Diastolic dysfunction							
Yes	12	66.67	6	85.7	18	72.0	0.6257
No	6	33.33	1	14.3	7	28.0	
Left atrial dilation							
Yes	5	27.78	3	42.9	8	32.0	0.6395
No	13	72.22	4	57.1	17	68.0	
Hypertrophy							
Yes	5	27.78	2	28.6	7	28.0	0.9931
No	13	72.22	5	71.4	18	72.0	
Aortic root dilatation							
Yes	3	16.67	–	–	3	12.0	0.5343
No	15	83.33	7	100.0	22	88.0	
Segmental dysfunction							
Yes	–	–	2	28.6	2	8.0	0.07
No	18	100	5	71.4	23	92.0	
Elevated PSAP							
Yes	1	5.556	1	14.3	2	8.0	0.49
No	17	94.44	6	85.7	23	92.0	
Systolic dysfunction							
Yes	–	–	1	14.3	1	4.0	0.28
No	18	100	6	85.7	24	96.0	
Right atrial dilation							
Yes	1	5.556	–	–	1	4.0	1.0
No	17	94.44	7	100.0	24	96.0	

*Source: Research protocol. Dashes (–) indicate a value of zero, not resulting from rounding. PSAP: pulmonary artery systolic pressure. %: Frequency; N: Records analyzed. * Fisher's exact test.*

Conclusions

The vast majority of patients hospitalized for COVID-19 analyzed in this study had abnormal echocardiographic findings, with diastolic dysfunction being the most frequent. Among those who died, at least one echocardiographic abnormality was detected.

The cardiovascular complications observed included atrial fibrillation and flutter, decompensated heart failure, and cardiogenic shock. However, these complications were not present in patients with normal echocardiographic findings.

Although a likely trend toward increased mortality from SARS-CoV-2 infection can be inferred among patients who experienced cardiovascular complications, the small sample size of this study limits the statistical strength of the associations. Accordingly, the present study serves an exploratory purpose in depicting the reality of the North Region of Brazil during the COVID-19 pandemic.

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Author Contributions

Conception and design of the research: : Almeida JHA, Ferreira GMA, Andrade MAM, Nunes HM, Costa IB; acquisition of data: Almeida JHA, Andrade MAM; analysis and interpretation of the data: Almeida JHA, Ferreira GMA; statistical analysis: Almeida JHA; writing of the manuscript: Almeida JHA, Ferreira GMA, Andrade MAM; critical revision of the manuscript for intellectual content: Ferreira GMA, Nunes HM, Costa IB; manuscript formatting: Ferreira GMA; supervision: Nunes HM; co-supervision: Costa IB.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This article is part of the thesis of master submitted by João Henrique Andrade de Almeida, from Instituto Evandro Chagas.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Instituto Evandro Chagas under the protocol number 5.540.025. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

The underlying content of the research text is contained within the manuscript.

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