Original Article

ST-Segment Elevation Myocardial Infarction Metrics Before and During the COVID-19 Pandemic: Experience from a Brazilian Center

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Abstract

Background: **The impact of the COVID-19 pandemic on the healthcare of patients with ST-segment elevation acute myocardial infarction (STEMI) in Brazil remains unclear.**

Objective: **Provide a descriptive analysis of clinical profiles, time intervals, performance metrics, and outcomes in patients with STEMI before and during the COVID-19 pandemic.**

Methods: **Among a cohort of 193 patients with STEMI diagnosed in five emergency departments within a single Brazilian healthcare network, 187 patients were included between January 2017 and April 2021 and stratified into two cohorts: Cohort I (pre-pandemic, 146 patients) and Cohort II (pandemic, 41 patients). Statistical significance was defined as a two-sided p value < 0.05.**

Results: **The mean age of the participants was 62.7 years (standard deviation: 13.2); 83.4% were male, and 86.1% underwent primary percutaneous coronary intervention (PCI). Duration from symptom onset to emergency department presentation was 60 minutes in both cohorts (interquartile range, IQR: 30 to 150 in Cohort I versus 30 to 152 in Cohort II, p = 0.273). Total ischemic time was 132 minutes in Cohort I (IQR: 94 to 222), and 117 minutes in Cohort II (IQR: 76.3 to 185.6) (p = 0.159). The observed STEMI time delays and performance metrics were comparable between groups, with reperfusion rates within the recommended time frame above 90% in both cohorts. Hospital mortality was 3.4% in Cohort I and 7.3% in Cohort II (p = 0.376).**

Conclusion: **In the context of the COVID-19 pandemic, within a private healthcare network system in Brazil, this study did not uncover statistically significant disparities in clinical profiles, time intervals, performance metrics, or in-hospital mortality when compared to the pre-pandemic period.**

Keywords: **ST Elevation Myocardial Infarction; Myocardial Reperfusion; Angioplasty; Fibrinolysis; COVID-19.**

Introduction

An organized in-hospital ST-segment elevation acute myocardial infarction (STEMI) network is essential for providing timely reperfusion therapy and improving outcomes.[1] The COVID-19 pandemic has overwhelmed emergency care centers and has been associated with delayed STEMI reperfusion, even in non-epicenter regions.[2] Several clinical and health system features jeopardized optimal care delivery in STEMI,[3,4] including the following: delayed emergency department presentation,[5] overloaded centers,[6] and concomitant COVID-19.[7,8] Vulnerable populations were particularly affected.[9]

In Brazil, the impact of the pandemic on healthcare systems has been devastating, with an alarming in-hospital mortality rate of 38% among the first 250,000 hospitalizations.[10] There was an increase in cardiovascular mortality in the public healthcare system due to cardiovascular disease in 2020 following the onset of the pandemic.[11] Additionally, as the healthcare system collapsed under the strain of the pandemic and patients hesitated to seek medical attention due to viral exposure concerns, there was a noticeable rise in unspecified cardiovascular events and deaths occurring at home.[12,13] Recognizing the pandemic's heterogeneity, there was an excess mortality rate among Black and multiracial individuals in Brazil, along with increasing excess mortality linked to a worsening health vulnerability index.[13,14] Although there have been numerous articles recently published on STEMI metrics during the pandemic in different countries,[15-19] there is a scarcity of data specific to the Brazilian context.[20-22]

In order to fill this knowledge gap, our study aimed to assess the impact of the COVID-19 pandemic on the management of STEMI care within a healthcare network in Brazil. We conducted a descriptive analysis of key STEMI quality measures, reperfusion strategies, and outcomes before and during the COVID-19 pandemic.

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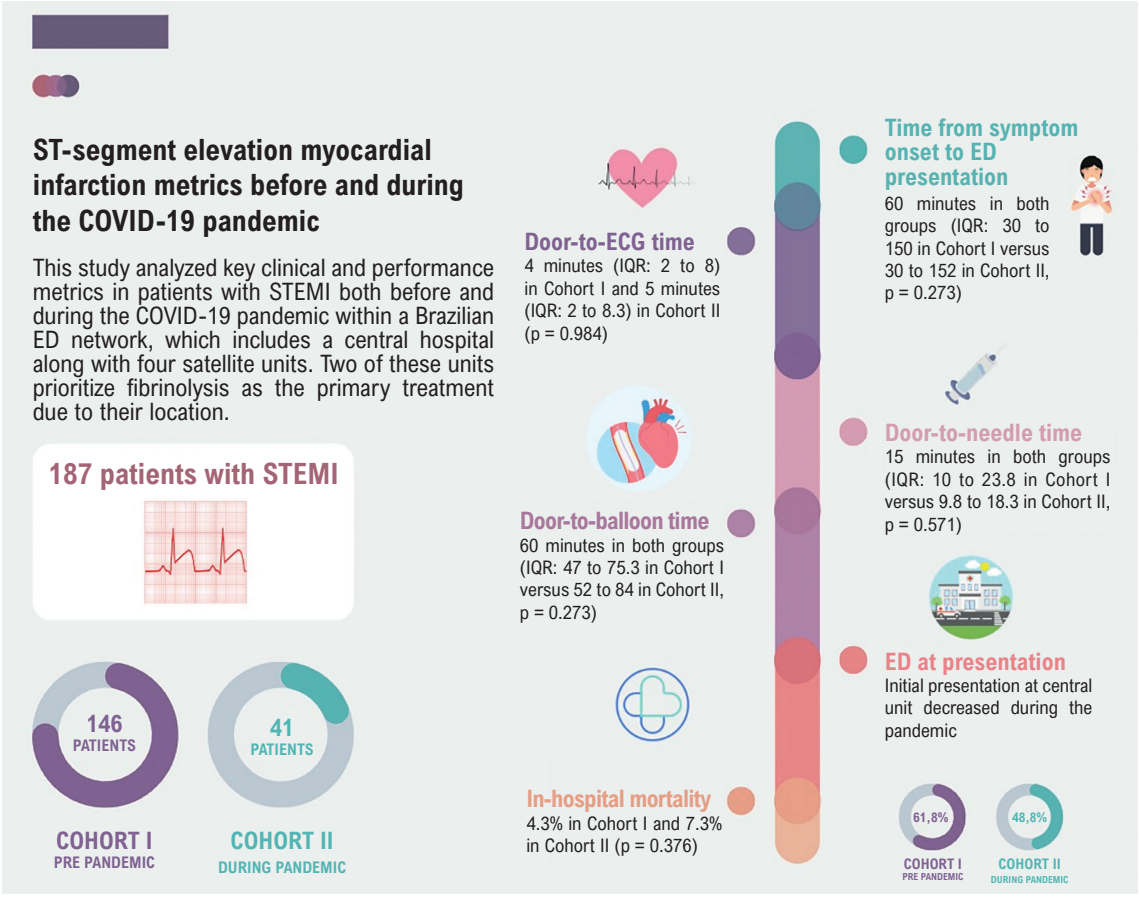
Central Illustration: ST-Segment Elevation Myocardial Infarction Metrics Before and During the COVID-19 Pandemic: Experience from a Brazilian Center



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ST-segment elevation myocardial infarction metrics before and during the COVID-19 pandemic. ED: emergency department; IQR: interquartile range; STEMI: ST-segment elevation acute myocardial infarction.

Methods

Study design and population

A single-center retrospective observational study was conducted at a private general healthcare network with five emergency departments in the metropolitan area of Sao Paulo, Brazil, from January 1, 2017 to April 23, 2021. The study population was divided into two cohorts: pre-pandemic (Cohort I), between January 1, 2017 and February 28, 2020, and pandemic (Cohort II), from February 29, 2020 to April 23, 2021. The study received approval from the ethics committee prior to initiation and was conducted in accordance with the Good Clinical Practice guidelines.

The revascularization strategy employed is determined by the location of admission. Our central hospital hosts the catheterization laboratory. Patients admitted directly to the central hospital and two of the four satellite units undergo primary percutaneous coronary intervention (PCI) as the default reperfusion strategy. Patients treated in the other two satellite units, due to their greater distance from the central hospital, are usually treated with fibrinolysis strategy followed by an immediate transfer for angiography and PCI (pharmaco-invasive strategy). Appendix Figure S1 displays the locations of the emergency departments in the metropolitan area. The hospital has been recognized by the National Cardiovascular Data Registry (NCDR®), American College of Cardiology, Chest Pain-MI Registry with a platinum performance achievement award for optimal care of patients with acute coronary syndrome. During the pandemic, STEMI care pathway guidance was established to ensure timely reperfusion for patients with STEMI. Recommendations also included adequate personal protection equipment for healthcare workers, streamlined logistical processes for transportation, catheterization laboratory preparation, and bed allocation while facilitating effective communication between healthcare

personnel. As part of routine care, a nasal swab reverse-transcriptase–polymerase-chain-reaction (RT-PCR) assay was collected for all patients with suspected STEMI upon admission.

Inclusion criteria

The study included participants aged 18 years or older who were admitted to any of the five emergency departments and received a clinical diagnosis of STEMI as their final diagnosis, without a concurrent COVID-19 infection.

Exclusion criteria

The exclusion criteria for the study encompassed several categories. Patients with contraindications to fibrinolysis admitted to satellite units where fibrinolysis was the preferred reperfusion method were excluded. Additionally, patients with specific non-system reasons for delays, such as difficult vascular access, ineligibility for PCI in emergency departments with a primary PCI strategy, and patients requiring emergency department intubation prior to reperfusion, were also excluded.

Data collection

A multidisciplinary team comprising nurses, clinical cardiologists, and interventional cardiologists closely monitors all patients with STEMI and routinely records their clinical in a dedicated database. Routinely collected data include demographic information, clinical variables, presentation characteristics, treatment metrics — time from door to electrocardiogram (ECG), time from door to needle, time from door to balloon, total ischemic time —, and in-hospital outcomes (peak high-sensitivity cardiac troponin T [hs-cTnT], left ventricular ejection fraction at discharge, length of stay, and hospital mortality). Additional data were collected by the study physicians from medical records, including comorbidity information obtained through manual hospital chart review. All participants' data were entered in Research Electronic Data Capture (REDCap)[23,24] and de-identified for statistical analysis.

Biomarker assay

For the present study, blood samples were collected in EDTA tubes and immediately processed. The levels of hs-cTnT were measured using a highly sensitive assay (Elecsys Troponin T hs STAT, Roche Diagnostics) on an automated platform (Cobas e 601 module). The assay has a lower detection limit of 3 pg/mL and a reported 99th percentile value of 14 pg/mL in apparently healthy individuals.

Study outcomes

The outcomes assessed were time from symptoms onset to emergency department presentation, performance metrics, adherence to American Heart Association/American College of Cardiology (AHA/ACC) STEMI quality measures,[25] troponin peak, left ventricular ejection fraction, and in-hospital mortality.

The AHA/ACC STEMI quality measures include door-to-ECG time < 10 minutes, door-to-device time ≤ 90 minutes for patients who presented at our PCI-capable hospital, door-to-device time ≤ 120 minutes for patients who presented at the satellite emergency departments, door-to-needle time < 30 minutes, late presenters (> 12 hours from symptom onset to emergency department visit), and a global quality measure (overall treatment within the recommended time).[25,26]

Statistical analysis

Categorical data were presented as absolute counts and corresponding percentages, while continuous variables were described using either mean and standard deviation or median and interquartile range (IQR), depending on their distribution characteristics. We assessed the normality of the data using the Shapiro-Wilk test. Between-group comparisons for continuous variables were evaluated using either unpaired Student's t test or the Mann-Whitney test, according to the distribution of the data. Proportions were compared using either the chi-square test or the Fisher test, depending on the appropriateness of the test for the specific data. Two-sided nominal p values were reported for all between-group comparisons, with statistical significance set at $p < 0.05$. All data analyses were conducted using R software, version 4.2.1 or higher (R Foundation for Statistical Computing).

Results

A total of 193 cases of STEMI were identified, of which 187 were included in the study. Exclusions included two patients with contraindications to fibrinolysis admitted to one of the satellite units where it is preferred, one patient with difficult vascular access, one patient who refused fibrinolysis, one who required sedation prior to PCI, and one who required intubation in the emergency department before PCI.

The mean (± standard deviation) age of included patients was 61.6 ± 13.4 years, and the majority (83.4%) were men. A total of 86 (46%) had dyslipidemia; 82 (43.9%) had hypertension, and 43 (23%) had diabetes mellitus. The total of current tobacco users was 27.3%, and 12.8% reported a previous history of smoking. Most patients presented in the first occurrence of first myocardial infarction (85.6%) and were classified as Killip I (91.3%). Primary PCI was the primary reperfusion strategy in most cases (86.1%). Demographic and clinical characteristics are displayed in Table 1.

The time from symptom onset to emergency department presentation was 60 minutes (IQR: 30 to 150) in Cohort I and 60 minutes (IQR: 30 to 152) in Cohort II ($p = 0.273$). The time from door-to-ECG was 4 minutes (IQR: 2 to 8) in Cohort I and 5 minutes (IQR: 2 to 8.3) in Cohort II ($p = 0.984$). Both groups had a door-to-needle time of 15 minutes. Median door-to-balloon times were 60 minutes (IQR: 47 to 75.3) in Cohort I and 67 minutes (IQR: 52 to 85) in Cohort II. Total ischemic times were 132 minutes (IQR: 94 to 222) for Cohort I and 117 minutes (IQR: 76.3 to 185.6) for Cohort II. Detailed STEMI time-delay metrics are displayed in Table 2.

Before the pandemic, most individuals' (61.6%) initial presentation occurred at the central hospital, while 28.8% presented at PCI-treatment satellite units, and 9.6% at fibrinolysis-treatment satellite units. During the pandemic, there was a noticeable shift, with 48.8% presenting at the central hospital, 22% at PCI-treatment satellite units, and 29.3% at fibrinolysis-treatment satellite units. This shift reflects a reduction

Table 1 – Baseline characteristics of the study population

Characteristics	Overall (n = 187)	Cohort I – pre-pandemic (n = 146)	Cohort II – pandemic (n = 41)	p value*
Age, mean (SD), y	61.6 ± 13.4	61.4 ± 13.5	62.7 ± 13.2	0.744
Male sex, No. (%)	156 (83.4)	123 (84.3)	33 (80.5)	0.567
Hypertension, No. (%)	82 (43.9)	63 (43.2)	19 (46.3)	0.716
Diabetes mellitus, No. (%)	43 (23.0)	28 (19.2)	15 (36.6)	0.019
Dyslipidemia, No. (%)	86 (46.0)	63 (43.2)	23 (56.1)	0.142
Chronic kidney disease, No. (%)	10 (5.5)	9 (6.3)	1 (2.4)	0.461
Previous stroke or TIA, No. (%)	5 (2.7)	4 (2.7)	1 (2.4)	>0.99
Previous myocardial infarction, No. (%)	27 (14.4)	21 (14.4)	6 (14.6)	0.968
Previous revascularization, No. (%)				
PCI	24 (12.8)	17 (11.6)	7 (17.1)	0.510
Previous CABG	6 (3.2)	4 (2.7)	2 (4.9)	
Previous CABG and PCI	3 (1.6)	3 (2.1)	0 (0)	
HIV infection, No. (%)‡	4 (2.2)	4 (2.8)	0 (0)	0.577
Smoking status, No. (%)				
Current tobacco user	51 (27.3)	40 (27.4)	11 (26.8)	0.985
Previous tobacco user	24 (12.8)	19 (13.0)	5 (12.2)	
Primary PCI treatment, No. (%)	161 (86.1)	132 (90.4)	29 (70.7)	0.001
Killip Class on presentation, No. (%)‡				
I	168 (91.3)	132 (92.3)	36 (87.8)	0.28
II	7 (3.8)	5 (3.5)	2 (4.9)	
III	3 (1.6)	3 (2.1)	0 (0)	
IV	6 (3.2)	3 (2.1)	3 (7.3)	
Systolic blood pressure (mmHg) at presentation†	139.5 ± 29.7	138.8 ± 27.9	142.0 ± 35.5	0.450
Heart rate (bpm) at presentation†	77.9 ± 18.8	78.1 ± 18.5	77.3 ± 19.9	0.958

*CABG: coronary artery bypass graft; No.: number; PCI: percutaneous coronary intervention; SD: standard deviation; TIA: transient ischemic attack. * Between-group comparisons. P values were not adjusted for multiple comparisons. ‡ Data were available from 184 participants. ** Data were available from 183 participants. † Data were available from 185 participants.*

in presentations to units where primary PCI is the preferred strategy, accompanied by an increase in fibrinolysis use due to presentations at fibrinolysis-treatment emergency departments. The proportion of participants achieving door-to-device times of less than 60 minutes were also numerically lower during the pandemic. Late-presenting patients, defined as time from symptom onset to emergency department admission > 12 hours, were infrequent in both cohorts, with similar time from symptom onset to emergency department presentation (60 minutes) in both study periods.

In-hospital outcomes are detailed in Table 3. Median hospital length of stay was 1 day shorter during the pandemic. No significant differences were noted in peak hs-cTnT levels or left ventricular ejection fraction at discharge between the two cohorts. In-hospital mortality was slightly higher during the pandemic, but between-group comparison was limited due to the low number of observed events. All recorded deaths were attributed to cardiovascular complications of STEMI. Importantly, no patients were diagnosed with COVID-19 upon admission. A summary of the main findings is provided in the Central Figure.

Discussion

During the COVID-19 pandemic, we did not observe any major disruptions in STEMI-related time delays, quality measures, or outcomes in our healthcare network. This consistency might be attributed to the implementation of a systematic quality improvement approach through process benchmarking in STEMI management since 2012.[27] In response to the pandemic, various measures were put in place to uphold the quality of care, including staff training, on-site SARS-CoV-2 testing, and the

Table 2 – STEMI time delays and metrics

STEMI Delays and performance metrics*	Overall (n = 187)	Cohort I – pre-pandemic (n = 146)	Cohort II – pandemic (n = 41)	p value**
Time from symptom onset to ED presentation, median (IQR), min†	60 (30-150)	60 (30-152)	60 (30-99)	0.273
Late presentation, No./total (%)	7/181 (3.9)	4/140 (2.9)	3/41 (7.3)	0.193
Time from door to ECG, median (IQR), min‡	4 (2-8)	4 (2-8)	5 (2-8.3)	0.984
Time from door to needle, median (IQR), min§	15 (10-19.8)	15 (10.3-23.8)	15 (9.8-18.3)	0.571
Time from door to balloon, median (IQR), min¶	60 (48-77)	60 (47-75.3)	67 (52-84)	0.116
Total ischemic time, median (IQR), min‖	129 (89-218)	132 (94-222)	117 (76.3-185.6)	0.159
Participants with door-to-ECG time < 10 min, No./total (%)	164/185 (88.7)	128/145 (88.2)	36/40 (90.0)	>0.999
Participants with door-to-device within recommended time, No./total (%)	152/161 (94.4)	127/132 (96.2)	25/29 (86.2)	0.056
Participants with door-to-needle within recommended time, No./total (%)	23/26 (88.5)	11/14 (78.6)	12/12 (100.0)	0.225
Overall reperfusion within recommended time, No./total (%)	175/187 (92.8)	138/146 (94.5)	37/41 (90.2)	0.232
Overall treatment within recommended time, No./total (%)	155/185 (83.8)	122/145 (84.1)	33/40 (82.5)	0.811

*ECG: electrocardiogram; ED: emergency department; IQR: interquartile range; No.: number; STEMI: ST-segment elevation acute myocardial infarction. * Metrics based on the ACC/AHA STEMI guidelines. ** Between-group comparisons. Reported nominal p values were not adjusted for multiple comparisons and should be considered exploratory. † Data were available from 181 participants. ‡ Data were available from 185 participants. § Data were available from 12 participants in the pre-pandemic group and 26 participants overall. ¶ Data were available from 29 participants in the pre-pandemic group and 161 participants overall. ‖ Data were available from 40 participants in the pre-pandemic group and 179 participants overall.*

Table 3 – In-hospital outcomes

In-hospital outcomes and key laboratory findings	Overall (n = 187)	Cohort I – pre-pandemic (n = 146)	Cohort II – pandemic (n = 41)	p value*
Peak hs-cTnT, median (IQR), ng/L†	2418 (910.5-4744)	2295 (1063.5-4572.5)	2448.5 (945.8-5411)	0.944
LVEF at discharge, median (IQR), %‡	56 (47-60)	56 (46-60)	56 (49-60)	0.741
Hospital mortality, No. (%)	8 (4.3)	5 (3.4)	3 (7.3)	0.376
Hospital length of stay, median (IQR), days§	5 (4-6)	5 (4-7)	4 (3-5)	0.049

*hs-cTnT: high-sensitivity cardiac troponin T; IQR: interquartile range; LVEF: left ventricular ejection fraction; No.; number. * Between-group comparisons. Reported nominal p values were not adjusted for multiple comparisons and should be considered exploratory. † Data were available from 67 participants, 40 participants in the pandemic and 27 in the pre-pandemic group. ‡ Data were available from 173 participants. § Data for participants who were discharged alive from hospital.*

activation of catheterization laboratories following national and international guidelines,[28-30] which included the establishment of a dedicated COVID-19 room.

In a Brazilian university hospital, Silva et al.[22] identified medium time from symptom onset to emergency department presentation of 298 ± 158.5 minutes, and there was no difference between groups before and during the pandemic (p = 0.58). Additionally, the percentage of cases presenting after 12 hours was comparable (5.9 pre-pandemic versus 13.8% during the pandemic, p = 0.40), and the percentage of STEMI cases reduced by 14.8% during the pandemic. However, performance metrics were not evaluated. In our study, there was a shorter time to emergency department presentation (60 minutes for both periods) and a low

incidence of late presentation (only 3.9% of the overall population). This difference possibly reflects an increased awareness and recognition of potentially serious symptoms in our population.

Ayad et al., at a single center in Egypt, showed higher in-hospital mortality, higher rate of reinfarction, greater need for revascularization, and longer hospital stay.[31] A recent meta-analysis of 61 observational studies with 125,346 patients quantified trends of patients with STEMI during the first wave of the pandemic and showed a 24% reduction in hospitalizations, higher in-hospital mortality, increased time delays, and worse in-hospital outcomes.[32] Another meta-analysis of 15 cross-sectional studies including 20,528 patients found younger patients presenting at the emergency department, increased time from symptom onset to admission, and lower left ventricular ejection fraction at presentation (2.24%), but they did not find any difference regarding door-to-balloon time compared to the historical period.[33] Paradoxically, some centers documented a significant decrease in door-to-balloon time during the pandemic, which could be attributed to decreased emergency department utilization, especially during the first COVID-19 wave.[34]

Following the onset of the pandemic, patients with chest pain diagnosed with STEMI avoided the emergency department of our central hospital, which was concurrently admitting COVID-19 patients. Furthermore, the median hospital stay was reduced by 1 day. These trends may be linked to various factors, including the possibility of getting infected with COVID-19 among healthcare workers and other patients, strict social and healthcare containment measures, and a sense of altruism among individuals to alleviate a strained healthcare system.

A Brazilian study that examined data of 149 patients with acute coronary syndrome showed that patients with COVID-19 had a risk of death 2 times higher than those without COVID-19. The study included 36 participants who had both STEMI and COVID-19 and 12 who had STEMI without COVID-19. However, metrics such as duration of symptoms, quality of care, and outcomes for this subgroup were not studied.[17] In our study, we did not evaluate the relationship between COVID-19 and worse outcomes, as none of the patients in our sample had confirmed SARS-CoV-2 infection.

Several limitations should be acknowledged in this study. Firstly, the number of cases during the pandemic was limited and smaller than the number observed in the pre-pandemic period, which restricted our ability to further explore the data according to specific time periods, such as periods of lockdown or stratification by the five emergency departments. Furthermore, it is worth highlighting the shorter observation timeframe between the two periods under study. Secondly, the evaluation of STEMI care was performed in a single center that is embedded, but not integrated within a very heterogeneous healthcare system; therefore, our findings should not be extrapolated to represent global STEMI care in Brazil. Thirdly, due to our relatively small sample size, we acknowledge that our study may not have had sufficient statistical power to rule out potential adverse effects of the COVID-19 pandemic on STEMI metrics and outcomes. Also, due to the occurrence of very few events, we were unable to evaluate group effects on hospital mortality while accounting for potential confounding factors. Fourthly, no adjustment for multiple testing was performed, and p values should be interpreted as exploratory. Lastly, since the analysis only included patients who went to the emergency department, the impact of social isolation, healthcare collapse, and mandatory quarantine on the behavior of patients with STEMI could not be evaluated. Nonetheless, time from symptom onset to emergency department visit, frequency of late presenters, and most STEMI time-delay metrics were similar in both time periods.

Conclusion

In summary, our descriptive study suggests that the COVID-19 pandemic did not have a negative impact on the quality of care and outcomes for patients presenting with STEMI who were treated at a healthcare network in Brazil.

Author Contributions

Conception and design of the research: Tavares CAM, Accorsi TAD, Paixão MR, Souza Jr JL; acquisition of data: Paixão MR, Mota T, Pitta F, Lemos PA, Franken M, Lima KA, Kohler KF, Souza Jr JL; analysis and interpretation of the data: Tavares CAM, Accorsi TAD, Paixão MR, Mota T, Pitta F, Lemos PA, Franken M, Souza Jr JL; statistical analysis: Tavares CAM, Accorsi TAD, Paixão MR; writing of the manuscript and critical revision of the manuscript for intellectual contente: Tavares CAM, Accorsi TAD, Paixão MR, Mota T, Pitta F, Lemos PA, Franken M, Lima KA, Kohler KF, Souza Jr JL; administrative and material support: Lima KA, Kohler KF.

Potential Conflict of Interest

Dr. Tavares reported receiving lecture fees from Novo Nordisk, outside the submitted work. Dr. Lemos reported lecture and consulting fees from Boston Scientific, BBraun, and Edwards, as well as a research grant from Novo Nordisk, outside the submitted work. Dr. Pitta reported speaker fees from Siemens, outside the submitted work. No other disclosures were reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Sociedade Beneficente Israelita Brasileira Hospital Albert Einstein under the protocol number 4.960.707. All the procedures in this study were in accordance with the 1975

Helsinki Declaration, updated in 2013. A waiver of consent was granted by the ethics committee.

Use of Artificial Intelligence

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

Availability of Research Data and Other Materials

Deidentified data can be made available upon reasonable request to the corresponding author. Access will be granted for specific purposes, outlined in a brief study protocol or rationale, and will require approval from the study leadership. Institutional approval will also be necessary.

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***Supplemental Materials**

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