Acute STEMI During the COVID-19 Pandemic at a Regional Hospital: Incidence, Clinical Characteristics, and Outcomes

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ABSTRACT

Objectives: The aim of this study was to describe the characteristics and in-hospital outcomes of patients with acute ST-segment elevation myocardial infarction (STEMI) during the early COVID-19 pandemic at Piedmont Athens Regional (PAR), a 330-bed tertiary referral center in Northeast Georgia.

Methods: A retrospective study was conducted at PAR to evaluate patients with acute STEMI admitted over an 8-week period during the initial COVID-19 outbreak. This study group was compared to patients admitted during the corresponding period in 2019. The primary endpoint of this study was defined as a composite of sustained ventricular arrhythmia, congestive heart failure (CHF) with pulmonary congestion, and/or in-hospital mortality.

Results: This study cohort was composed of 64 patients with acute STEMI; 30 patients (46.9%) were hospitalized during the COVID-19 pandemic. Patients with STEMI in both the COVID-19 and control groups had similar comorbidities, Killip classification score, and clinical presentations. The median (interquartile range) time from symptom onset to reperfusion (total ischemic time) increased from 99.5 minutes (84.8-132) in 2019 to 149 minutes (96.3-231.8; $P = .032$) in 2020. Hospitalization during the COVID-19 period was associated with an increased risk for combined in-hospital outcome (odds ratio, 3.96; $P = .046$).

Conclusion: Patients with STEMI admitted during the first wave of the COVID-19 outbreak experienced longer total ischemic time and increased risk for combined in-hospital outcomes compared to patients admitted during the corresponding period in 2019.

Keywords: myocardial infarction, acute coronary syndrome, hospitalization, outcomes.

The emergence of the SARS-Cov-2 virus in December 2019 caused a worldwide shift in resource allocation and the restructuring of health care systems within the span of a few months. With the rapid spread of infection, the World Health Organization officially declared a pandemic in March 2020. The pandemic led to the deferral and cancellation of in-person patient visits, routine diagnostic studies, and nonessential surgeries and procedures. This response occurred secondary to a joint effort to reduce transmission via stay-at-home mandates and appropriate social distancing.[1]

Alongside the reduction in elective procedures and health care visits, significant reductions in hospitalization rates due to decreases in acute ST-segment elevation myocardial infarction (STEMI) and catheterization laboratory utilization have been reported in many studies from around the world.[2-7] Comprehensive data demonstrating the impact of the COVID-19 pandemic on acute STEMI patient characteristics, clinical presentation, and in-hospital outcomes are lacking. Although patients with previously diagnosed cardiovascular disease are more likely to encounter worse outcomes in the setting of COVID-19, there may also be an indirect impact of the pandemic on high-risk patients, including those without the infection.[8] Several theories have been hypothesized to explain this phenomenon. One theory postulates that the fear of contracting the virus during hospitalization is great enough to prevent patients from seeking care.[2]

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Another theory suggests that the increased utilization of telemedicine prevents exacerbation of chronic conditions and the need for hospitalization.[9] Contrary to this trend, previous studies have shown an increased incidence of acute STEMI following stressful events such as natural disasters.[10]

The aim of this study was to describe trends pertaining to clinical characteristics and in-hospital outcomes of patients with acute STEMI during the early COVID-19 pandemic at Piedmont Athens Regional (PAR), a 330-bed tertiary referral center in Northeast Georgia.

Methods

A retrospective cohort study was conducted at PAR to evaluate patients with STEMI admitted to the cardiovascular intensive care unit over an 8-week period (March 5 to May 5, 2020) during the COVID-19 outbreak. COVID-19 was declared a national emergency on March 13, 2020, in the United States. The institutional review board at PAR approved the study; the need for individual consent was waived under the condition that participant data would undergo de-identification and be strictly safeguarded.

Data Collection

Because there are seasonal variations in cardiovascular admissions, patient data from a control period (March 9 to May 9, 2019) were obtained to compare with data from the 2020 period. The number of patients with the diagnosis of acute STEMI during the COVID-19 period was recorded. Demographic data, clinical characteristics, and primary angiographic findings were gathered for all patients. Time from symptom onset to hospital admission and time from hospital admission to reperfusion (defined as door-to-balloon time) were documented for each patient. Killip classification was used to assess patients' clinical status on admission. Length of stay was determined as days from hospital admission to discharge or death (if occurring during the same hospitalization).

Adverse in-hospital complications were also recorded. These were selected based on inclusion of the following categories of acute STEMI complications: ischemic, mechanical, arrhythmic, embolic, and inflammatory. The following complications occurred in our patient cohort: sustained ventricular arrhythmia, congestive heart failure (CHF) defined as congestion requiring intravenous diuretics, re-infarction, mechanical complications (free-wall rupture, ventricular septal defect, or mitral regurgitation), second- or third-degree atrioventricular block, atrial fibrillation, stroke, mechanical ventilation, major bleeding, pericarditis, cardiogenic shock, cardiac arrest, and in-hospital mortality. The primary outcome of this study was defined as a composite of sustained ventricular arrhythmia, CHF with congestion requiring intravenous diuretics, and/or in-hospital mortality. Ventricular arrythmia and CHF were included in the composite outcome because they are defined as the 2 most common causes of sudden cardiac death following acute STEMI.[11,12]

Statistical Analysis

Normally distributed continuous variables and categorical variables were compared using the paired *t*-test. A 2-sided *P* value <.05 was considered to be statistically significant. Mean admission rates for acute STEMI hospitalizations were determined by dividing the number of admissions by the number of days in each time period. The daily rate of COVID-19 cases per 100,000 individuals was obtained from the Centers for Disease Control and Prevention COVID-19 database. All data analyses were performed using Microsoft Excel.

Results

The study cohort consisted of 64 patients, of whom 30 (46.9%) were hospitalized between March 5 and May 5, 2020, and 34 (53.1%) who were admitted during the analogous time period in 2019. This reflected a 6% decrease in STEMI admissions at PAR in the COVID-19 cohort.

Acute STEMI Hospitalization Rates and COVID-19 Incidence

The mean daily acute STEMI admission rate was 0.50 during the study period compared to 0.57 during the control period. During the study period in 2020 in the state of Georgia, the daily rate of newly confirmed COVID-19 cases ranged from 0.194 per 100,000 on March 5 to 8.778 per 100,000 on May 5. Results of COVID-19 testing were available for 9 STEMI patients, and of these 0 tests were positive.

Table 1. **Baseline Characteristics of Patients With STEMI Before and During the COVID-19 Pandemic**

Baseline characteristics	Total (N=64)	COVID-19 period (n=30)	Control period (n=34)	*P* value
Age, median (IQR), y	60 (51-72)	62 (53-74)	59 (49-65)	.073
Female gender	16 (25)	9 (30)	7 (20.5)	.394
Comorbidities				
Diabetes mellitus	24 (37.5)	14 (46.7)	10 (29.4)	.160
Hypertension	48 (75)	25 (83.3)	23 (67.6)	.153
Dyslipidemia	56 (87.5)	28 (93.3)	28 (82.4)	.190
Current smoker	31 (48.4)	15 (50)	16 (47.1)	.818
Prior chronic kidney disease	4 (6.3)	2 (6.7)	2 (5.9)	.899
Prior myocardial infarction	13 (20.3)	7 (23.3)	6 (17.6)	.580
Prior CABG	3 (4.7)	3 (10)	0 (0)	.060
Prior peripheral arterial disease	3 (4.7)	2 (6.7)	1 (2.9)	.489
Prior congestive heart failure	7 (10.9)	5 (16.7)	2 (5.9)	.173
Prior stroke/transient ischemic attack	8 (12.5)	6 (20)	2 (5.9)	.091

All results are expressed as No. (%), except where noted.
CABG, coronary artery bypass grafting; IQR, interquartile range; STEMI, ST-segment elevation myocardial infarction.

Baseline Characteristics

Baseline characteristics of the acute STEMI cohorts are presented in **Table 1**. Approximately 75% were male; median (interquartile range [IQR]) age was 60 (51-72) years. There were no significant differences in age and gender between the study periods. Three-quarters of patients had a history of hypertension, and 87.5% had a history of dyslipidemia. There was no significant difference in baseline comorbidity profiles between the 2 study periods; therefore, our sample populations shared similar characteristics.

Clinical Presentation

Significant differences were observed regarding the time intervals of STEMI patients in the COVID-19 period and the control period (**Table 2**). Median time from symptom onset to hospital admission (patient delay) was extended from 57.5 minutes (IQR, 40.3-106) in 2019 to 93 minutes (IQR, 48.8-132) in 2020; however, this difference was not statistically significant ($P=.697$). Median time from hospital admission to reperfusion (system delay) was prolonged from 45 minutes (IQR, 28-61) in 2019 to 78 minutes (IQR, 50-110) in 2020 ($P<.001$). Overall time from symptom onset to reperfusion (total ischemic time) increased from 99.5 minutes (IQR, 84.8-132) in 2019 to 149 minutes (IQR, 96.3-231.8) in 2020 ($P=.032$).

Regarding mode of transportation, 23.5% of patients in 2019 were walk-in admissions to the emergency department. During the COVID-19 period, walk-in admissions decreased to 6.7% ($P=.065$). There were no significant differences between emergency medical service, transfer, or in-patient admissions for STEMI cases between the 2 study periods.

Killip classification scores were calculated for all patients on admission; 90.6% of patients were classified as Killip Class 1. There was no significant difference between hemodynamic presentations during the COVID-19 period compared to the control period.

Angiographic Data

Overall, 53 (82.8%) patients admitted with acute STEMI underwent coronary angiography during their hospital stay. The proportion of patients who underwent primary reperfusion was greater in the control period than in the COVID-19 period (85.3% vs 80%; $P=.582$). Angiographic characteristics and findings were similar between the 2 study groups (**Table 2**).

Table 2. **Clinical Presentation and Angiographic Findings in Patients With STEMI Before and During the COVID-19 Pandemic**

Clinical characteristics	Total (N=64)	COVID-19 period (n=30)	Control period (n=34)	*P* value
Time parameters				
Symptom onset to hospital admission, median (IQR), min	69.5 (41.3-127.5)	93 (48.8-132)	57.5 (40.3-106)	.697
Hospital admission to reperfusion, median (IQR), min	51 (33-75)	78 (50-110)	45 (28-61)	.0004
Symptom onset to reperfusion, median (IQR), min	117 (90.8-219.8)	149 (96.3-231.8)	99.5 (84.8-132)	.032
Mode of transportation, No. (%)				
Walk-in	10 (15.6)	2 (6.7)	8 (23.5)	.065
Emergency medical service	35 (54.7)	19 (63.3)	16 (47.1)	.198
Transfer	17 (26.6)	8 (26.7)	9 (26.5)	.986
Inpatient	2 (3.3)	1 (3.3)	1 (2.9)	.930
Killip classification at admission, No. (%)				
1	58 (90.6)	27 (90)	31 (91.2)	.874
2	5 (7.8)	3 (10)	2 (5.9)	.548
3	0	0 (0)	0 (0)	—
4	1 (1.6)	0 (0)	1 (2.9)	.352
Admission heart rate, median (IQR), bpm,	79 (65-91)	85 (66-98)	72 (64-84)	.205
Admission systolic BP, mean (SD), mm Hg,	137 (31)	134 (30)	141 (32)	.314
Admission diastolic BP, median (IQR), mm Hg	88 (75-100)	83 (72-99)	88 (81-100)	.281
Primary reperfusion, No. (%)	53 (82.8)	24 (80)	29 (85.3)	.582
Total angiography during hospitalization, No. (%)	53 (82.8)	24 (80)	29 (85.3)	.582
Number of diseased vessels, No. (%)				
1	47 (73.4)	22 (73.3)	25 (73.5)	.986
2	6 (9.4)	2 (6.7)	4 (11.8)	.493
3	1 (1.6)	1 (3.3)	0 (0)	.291
MINOCA	10 (15.6)	5 (16.7)	5 (14.7)	.833
Infarct-related artery, No. (%)				
LAD	23	8 (33.3)	15 (46)	.270
LCx	8	5 (20.1)	3 (9)	.253
RCA	25	12 (50)	13 (39)	.560
OM2	4	2 (8.3)	2 (6)	.795
Ejection fraction, median (IQR)	52 (40-55)	47 (38-55)	53 (46-55)	.238
Length of hospitalization, median (IQR), d	2 (2-3)	3 (2-3)	2 (2-3)	.899

BP, blood pressure; IQR, interquartile range; LAD, left anterior descending; LCx, left circumflex; MINOCA, myocardial infarction with nonobstructive coronary arteries; OM2, obtuse marginal; RCA, right coronary artery; STEMI, ST-segment elevation myocardial infarction.

In-Hospital Outcomes

In-hospital outcome data were available for all patients. As shown in **Table 3**, hospitalization during the COVID-19 period was independently associated with an increased risk for combined in-hospital outcome (odds ratio, 3.96; *P*=.046). The rate of in-hospital mortality was greater in the COVID-19 period (*P*=.013). We found no significant difference when comparing secondary outcomes from admissions during the COVID-19 period and the control period in 2019. For the 5 patients who died during the study period, the primary diagnosis at death was acute STEMI complicated by CHF (3 patients) or cardiogenic shock (2 patients).

Table 3. **In-Hospital Outcomes of Patients With STEMI During the Covid-19 Pandemic**

Outcomes	COVID-19 period (n=30)	Control period (n=34)	Odds ratio	*P* value
Composite in-hospital outcome[a]	6.7 (22.2)	2.3 (6.7)	3.96	.046
Sustained ventricular arrythmia	7 (23.3)	3 (8.8)	3.14	.111
Congestive heart failure	8 (26.7)	4 (11.8)	2.73	.132
Mechanical complications[b]	1 (3.3)	0 (0)	—	.291
High-degree atrioventricular block	8 (26.7)	3 (8.8)	3.76	.060
Cardiogenic shock	12 (40)	8 (23.5)	2.17	.161
Cardiac arrest	5 (16.7)	2 (5.9)	3.20	.173
Atrial fibrillation	5 (16.7)	3 (8.8)	2.07	.352
Pericarditis	0 (0)	0 (0)	—	—
Re-infarction	2 (6.7)	3 (8.8)	0.74	.753
Stroke	0 (0)	0 (0)	—	—
Mechanical ventilation	5 (16.7)	5 (14.7)	1.16	.833
Major bleeding	1 (3.3)	1 (2.9)	0.88	.930
In-hospital mortality	5 (16.7)	0 (0)	—	.013

All results are expressed as No. (%).
[a]Composite in-hospital outcome was defined as sustained ventricular arrhythmia, congestive heart failure, and in-hospital mortality.
[b]Mechanical complications were defined as free-wall rupture, ventricular septal defect, and moderate-to-severe mitral regurgitation.

Discussion

This single-center retrospective study at PAR looks at the impact of COVID-19 on hospitalizations for acute STEMI during the initial peak of the pandemic. The key findings of this study show a significant increase in ischemic time parameters (symptom onset to reperfusion, hospital admission to reperfusion), in-hospital mortality, and combined in-hospital outcomes.

There was a 49.5-minute increase in total ischemic time noted in this study ($P=.032$). Though there was a numerical increase in time of symptom onset to hospital admission by 23.5 minutes, this difference was not statistically significant ($P=.697$). However, this study observed a statistically significant 33-minute increase in ischemic time from hospital admission to reperfusion ($P<.001$). Multiple studies globally have found a similar increase in total ischemic times, including those conducted in China and Europe.[13-15] Every level of potential delay must be considered, including pre-hospital, triage and emergency department, and/or reperfusion team. Pre-hospital sources of delays that have been suggested include "stay-at-home" orders and apprehension to seek medical care due to concern about contracting the virus or overwhelming the health care facilities. There was a clinically significant 4-fold decrease in the number of walk-in acute STEMI cases in the study period. In 2019, there were 8 walk-in cases compared to 2 cases in 2020 ($P=.065$). However, this change was not statistically significant. In-hospital/systemic sources of delays have been mentioned in other studies; they include increased time taken to rule out COVID-19 (nasopharyngeal swab/chest x-ray) and increased time due to the need for intensive gowning and gloving procedures by staff. It was difficult to objectively determine the sources of system delay by the reperfusion team due to a lack of quantitative data.

In the current study, we found a significant increase in in-hospital mortality during the COVID-19 period compared to a parallel time frame in 2019. This finding is contrary to a multicenter study from Spain that reported no difference in in-hospital outcomes or mortality rates among all acute coronary syndrome cases.[16] The worsening outcomes and prognosis may simply be a result of increased ischemic time; however, the virus that causes COVID-19 itself may play a role as well. Studies have found that SARS-Cov-2 infection places patients

at greater risk for cardiovascular conditions such as hypercoagulability, myocarditis, and arrhythmias.[17] In our study, however, there were no acute STEMI patients who tested positive for COVID-19. Therefore, we cannot discuss the impact of increased thrombus burden in patients with COVID-19. Piedmont Healthcare published a STEMI treatment protocol in May 2020 that advised increased use of tissue plasminogen activator (tPA) in COVID-19-positive cases; during the study period, however, there were no occasions when tPA use was deemed appropriate based on clinical judgment.

Our findings align with previous studies that describe an increase in combined in-hospital adverse outcomes during the COVID-19 era. Previous studies detected a higher rate of complications in the COVID-19 cohort, but in the current study, the adverse in-hospital course is unrelated to underlying infection.[18,19] This study reports a higher incidence of major in-hospital outcomes, including a 65% increase in the rate of combined in-hospital outcomes, which is similar to a multicenter study conducted in Israel.[19] There was a 2.3-fold numerical increase in sustained ventricular arrhythmias and a 2.5-fold numerical increase in the incidence of cardiac arrest in the study period. This phenomenon was observed despite a similar rate of reperfusion procedures in both groups.

Acute STEMI is a highly fatal condition with an incidence of 8.5 in 10,000 annually in the United States. While studies across the world have shown a 25% to 40% reduction in the rate of hospitalized acute coronary syndrome cases during the COVID-19 pandemic, the decrease from 34 to 30 STEMI admissions at PAR is not statistically significant.[20] Possible reasons for the reduction globally include increased out-of-hospital mortality and decreased incidence of acute STEMI across the general population as a result of improved access to telemedicine or decreased levels of life stressors.[20]

In summary, there was an increase in ischemic time to reperfusion, in-hospital mortality, and combined in-hospital outcomes for acute STEMI patients at PAR during the COVID period.

Limitations

This study has several limitations. This is a single-center study, so the sample size is small and may not be generalizable to a larger population. This is a retrospective observational study, so causation cannot be inferred. This study analyzed ischemic time parameters as average rates over time rather than in an interrupted time series. Post-reperfusion outcomes were limited to hospital stay. Post-hospital follow-up would provide a better picture of the effects of STEMI intervention. There is no account of patients who died out-of-hospital secondary to acute STEMI. COVID-19 testing was not introduced until midway in our study period. Therefore, we cannot rule out the possibility of the SARS-Cov-2 virus inciting acute STEMI and subsequently leading to worse outcomes and poor prognosis.

Conclusions

This study provides an analysis of the incidence, characteristics, and clinical outcomes of patients presenting with acute STEMI during the early period of the COVID-19 pandemic. In-hospital mortality and ischemic time to reperfusion increased while combined in-hospital outcomes worsened.

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