The Impact of the COVID-19 Pandemic on the Treatment of Myocardial Infarction: A Single Center Experience

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Abstract: Introduction: Early and timely management of myocardial infarction (MI) is an important determinant of prognosis. In this study, we evaluated the impact of the COVID-19 pandemic on MI treatment and outcomes. **Methods:** In this retrospective study, we compared all patients who presented with MI during the pandemic with a cohort of patients who presented during an equivalent period in 2019. **Results:** During the study period, 275 MI admissions met our inclusion criteria. When comparing MI encounters in 2020 with encounters in 2019, there were no significant differences in mortality (2.1% vs 4.5%, *P*=.274), cardiac arrest (5.7% vs 6.0%, *P*=.916), or ICU admissions (7.1% vs 7.5%, *P*=.892). There were no significant differences in modalities of treatment including cardiac catheterization (94.3% vs 95.5%, *P*=.652) or medical treatment alone (13.5% vs 18.7%, *P*=.241) in 2020 vs 2019. Referrals for coronary artery bypass surgery were significantly higher in 2020 than in 2019 (8.5% vs 3.0%, *P*=.050). When comparing patients who presented during the first 5 months of the pandemic with patients who presented in the last 5 months in 2020, there was a significantly lower rate of cardiac catheterization (90.5% vs 98.5%, *P*=.041), and a higher rate of medical treatment alone (18.9% vs 7.5%, *P*=.047). **Conclusion:** There was no significant difference in the outcomes of MI compared with the equivalent period in 2019. The first 5 months of the pandemic were associated with a significant decrease in rates of pursuing cardiac catheterization along with increased rates of medical treatment alone compared with the following 5 months.

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Introduction

Ischemic heart disease (IHD) is the leading cause of mortality in the United States.[1] Myocardial infarction (MI) is caused by cessation of blood flow to myocardium. MIs can be asymptomatic and, therefore, not detected, and may not cause devastating events leading to hemodynamic deterioration and death. Early and timely management of MI is an important determinant of prognosis and survival.[2]

The emergence of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) into a worldwide pandemic has dramatically changed the lives of people around the globe. The COVID-19 pandemic has been responsible for many catastrophic consequences, including economic, social, and health effects.[3] It is now known that COVID-19 can produce direct severe cardiovascular outcomes, including myocarditis, MI, pulmonary embolism, stroke, arrhythmias, and heart failure. Simultaneously, there has been a decrease in seeking care for acute conditions by non-COVID-19 patients, which is attributed to concerns of acquiring in-hospital COVID-19 infections.[4] In order to provide appropriate care for patients with COVID-19, patients with IHD must continue to receive advancements in care made over the past decades.

Although it was found that patients with COVID-19 and underlying cardiovascular disease are associated with a higher risk of mortality, most patients who seek cardiovascular care are not infected with COVID-19.[5] The COVID-19 pandemic and the related alarm state has significantly affected the whole healthcare system; for example: many countries have reported a decline in the rate of activation of ST-elevation MI (STEMI) from cardiac catheterization laboratories.[6,7]

To examine the impact of COVID-19 infections on cardiac care utilization, we conducted a retrospective observational study to evaluate the impact of the COVID-19 pandemic on MI treatment and outcomes by comparing MI encounters during the pandemic with encounters in the year before the pandemic.

Methods

Sample Selection

A retrospective chart review was performed for all patients diagnosed with MI who were admitted to Ascension Saint Agnes Hospital in Baltimore, Maryland, from March through December 2019 and March through December 2020. Initially, 678 encounters were identified based on ICD-10 revision codes (I-20, I-21, I-22, I-23, I-24, and I-25). We then identified patients with MI by reviewing the charts based on the diagnosis on the discharge summary. There were 275 admissions with MI that met our initial criteria (**Figure 1**).

The patients who were included in our study were all above age 18, nonpregnant, and diagnosed with MI (STEMI or non-STEMI [NSTEMI]) and had elevated troponin I or troponin T or had evidence of obstructive coronary artery disease on cardiac catheterization during their admission. The exclusion criteria included patients who were under age 19, were pregnant, had normal coronaries on cardiac catheterization, had demand ischemia (type 2 MI), did not undergo an ischemic workup while hospitalized, and those who left against medical advice or were referred to another hospital for further management.

We conducted direct chart reviews to collect the data of the 275 admissions that were included. We collected quantitative and qualitative data based on laboratory reports, physicians' notes, and imaging reports. A universal datasheet was formulated on REDCap to complete the variables for each patient.[8] All data were obtained from the encounter at which the patients presented with MI. Some of the patients had multiple MI encounters, and all encounters were included if they met our inclusion criteria. We combined all datasheets from all investigators into a single sheet before analysis.

Measures

We collected the following baseline characteristics of the included patients: sex, age, race, cigarette use, baseline ejection fraction (EF), and presenting symptoms (chest pain, shortness of breath, etc.). We also reported if the patients had any of the following: obesity, diabetes, hypertension, chronic obstructive pulmonary disease (COPD), atrial fibrillation (AF), coronary artery disease (CAD), heart failure, prior MI, prior percutaneous coronary intervention (PCI), previous coronary artery bypass graft (CABG) surgery, cancer, chronic liver disease, and chronic kidney disease.

We collected the following information as outcomes for our study: mortality, cardiac arrest, acute renal failure, EF after admission, and length of stay (LOS) in the hospital. We reported if the patients required intensive care unit (ICU) admission, intravenous vasopressors, mechanical ventilation, an intra-aortic balloon pump, or pacemaker insertion. We also reported the modalities of treatment including cardiac catheterization, PCI, medical treatment alone, or referral for CABG surgery.

IRB Information

IRB #2020-017: Trends and Severity of Myocardial Infarction during COVID-19 Pandemic: A Retrospective Study. The IRB Chair reviewed the protocol on Jul 17, 2020. The IRB approved the study under the expedited category. An amendment form was submitted to the IRB to extend the data collection period and was approved.

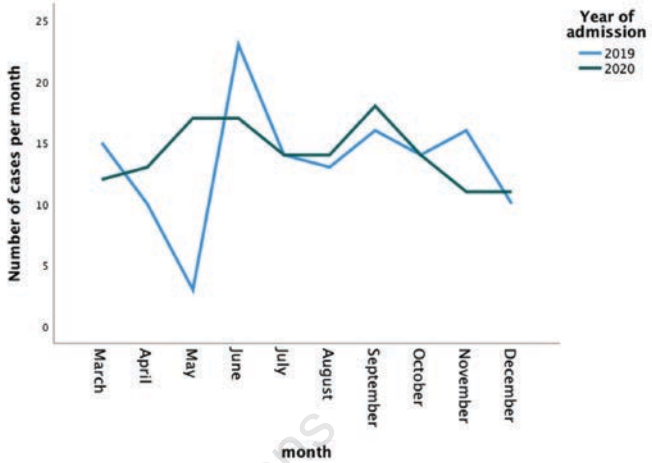

Figure 1. Number of cases per month.

Statistical Analysis

We reported the mean ± standard deviation on continuous variables and counts with percentages for categorical variables. We used independent samples T-test to compare continuous variables and chi-square for categorical variables. We ran a comparative analysis for each of the above-mentioned outcomes before and during the COVID-19 pandemic. We also performed a subgroup analysis of the MI encounters during the COVID-19 pandemic, comparing the encounters of the first 5 months (March through July) with encounters of the following 5 months (August through December) of the 2020 study period. Significance was accepted at a Type I level of error at $P \leq .05$. All analyses were conducted using Statistical Package for Social Sciences software version 25.

Results

During the study period of March through December 2019 and 2020, 275 MI admissions met our inclusion criteria (265 single encounters and 10 duplicate encounters). We had 141 encounters in 2020 and 134 encounters in 2019. There were 132 (48%) encounters with STEMI (50.7% in 2019 and 45.4% in 2020). There were 143 (52%) encounters with NSTEMI (49.3% in 2019 and 54.6% in 2020). The mean age of patients was 65.1 ± 12.6 years in the 2020 group vs 66.0 ± 13.8 years in the 2019 group. Most patients were Caucasian (56.7% in the 2020 group vs 51.5% in the 2019 group). Mean body mass index in the 2020 group was 31.7 ± 7.5 kg/m^2, and 30.4 ± 8.2 kg/m^2 in the 2019 group. The baseline EF before admission was 53.3 ± 33.8 in the 2020 group and 51.4 ± 12.5 in the 2019 group. Two patients tested positive for COVID-19 in the 2020 group. Most baseline characteristics were comparable in both groups except for diabetes (44.7% in 2020 vs 36.6% in 2019), COPD (15.6% in 2020 vs 4.5% in 2019), and chronic kidney disease (19.9% in 2020 vs 12.7% in 2019). Further details about the baseline characteristics of the included patients are shown in

Table 1. Baseline characteristics of patients admitted in 2019 and 2020 study periods.

	2019 (n = 134)	2020 (n = 141)
Male	84 (62.7%)	83 (58.9%)
Age	66.0 ± 13.8	65.1 ± 12.6
African American	69 (51.55)	57 (40.4%)
Caucasian	13 (9.7%)	80 (56.7%)
Other races	-	4 (2.9%)
Body mass index	30.4 ± 8.2	31.7 ± 7.5
Smoking	72 (53.7%)	84 (59.6%)
Diabetes	49 (36.6%)	63 (44.7%)
Hypertension	97 (72.4%)	110 (78.0%)
COPD	6 (4.5%)	22 (15.6%
Chronic heart failure	21 (15.8%)	29 (20.6%)
Ejection fraction	51.4 ± 12.5	53.3 ± 33.8
Myocardial infarction	34 (25.4%)	35 (24.8%)
Atrial fibrillation	10 (7.5%)	15 (10.6%)
Coronary artery disease	47 (35.1%)	55 (39.0%)
Cancer	15 (11.2%)	22 (15.6%)
Chronic kidney disease	17 (12.7%)	28 (19.9%)
Chronic liver disease	3 (2.2%)	10 (7.1%)
History of PCI	42 (31.3%)	49 (34.8%)
History of CABG	16 (11.9%)	12 (8.6%)
STEMI	68 (50.7%)	64 (45.4%)
NSTEMI	66 (49.3%)	77 (54.6%)
COVID-19	0 (0%)	2 (1.4%)

CABG = coronary artery bypass graft; COPD = chronic obstructive pulmonary disease; NSTEMI = non-ST-elevation myocardial infarction; PCI = percutaneous coronary intervention; STEMI = ST-elevation myocardial infarction

Table 1. There were no significant differences in the presenting symptoms of patients included in our study except for jaw pain (3.5% in 2020 vs 11.2% in 2019, *P*=.015), as shown in **Table 2**.

During the pandemic, the rates of MI admissions were 12 to 13 per month at the beginning of the pandemic in March and April, which is comparable to the rates in 2019 (10 to 15 cases per month). This increased to 17 per month in May and June 2020. The admission rates decreased to 14 per month in July and August before increasing again to 18 per month in September. After that, the rate stayed at 11 to 14 cases per month from October to December 2020 (**Figure 1**). When comparing encounters in 2020 (during the pandemic) with encounters in 2019. there were no significant differences in mortality (2.1% vs 4.5%, *P*=.274), cardiac arrest (5.7% vs 6.0%, *P*=.916), arrhythmias (14.2% vs 14.9%, *P*=.862), acute renal failure (14.9% vs 18.7%, *P*=.403), ICU admissions (7.1% vs 7.5%, *P*=.892), EF after admission (45.2 ± 14.8 vs 46.9 ± 13.5, *P*=.348), and LOS in the hospital (3.9 ± 3.2 vs 3.5 ± 2.3, *P*=.224). There were no significant differences in modalities of treatment including cardiac catheterization (94.3% vs 95.5%, *P*=.652), PCI (78.8% vs 78.4%, *P*=.945), or medical treatment alone (13.5% vs 18.7%, *P*=.241) in 2020 vs 2019. Referrals for CABG surgery were significantly higher in 2020 than in 2019 (8.5% vs 3.0%, *P*=.050), as shown in **Table 3**.

When comparing encounters in the first 5 months of the pandemic (March through July) with encounters in the last 5 months of the pandemic in 2020 (August through December), there were no significant differences in mortality (1.4% vs 3.0%, *P*=.502), cardiac arrest (6.0% vs 5.4%, *P*=.885), acute renal failure (17.3% vs 11.6%, *P*=.349), ICU admissions (5.4% vs 9.0%, *P*=.412), EF after admission (43.5 ± 15.1 vs 47.1 ± 14.2, *P*=.154), and LOS in the hospital (4.1 ± 3.8 vs 3.8 ± 2.5, *P*=.676). There was a significant increase in the rates of non-sustained ventricular tachycardia (NSVT) in encounters in the first 5 months of the pandemic compared with encounters in the following 5 months (8.1% vs 0.0%, *P*=.017) without a significant difference in the overall rate of arrhythmias (18.9% vs 9.0%, *P*=.090). There was a significant decrease in the rates of cardiac catheterization (90.5% vs 98.5%, *P*=.041), and a significant increase in the rates of medical treatment alone (18.9% vs 7.5%, *P*=.047) when comparing encounters in the first 5 months (March through July) with encounters in the following 5 months (August through December) of the pandemic in 2020 (**Table 4**).

Table 2. Presenting symptoms of patients admitted in the 2019 and 2020 study period.

Symptoms	2019 (n = 134)	2020 (n = 141)	*P*-value
Chest pain	131 (90.3%)	123 (87.2%)	.422
Abdominal pain	2 (1.5%)	2 (1.4%)	.959
Arm pain	22 (16.4%)	21 (14.9%)	.728
Neck pain	9 (6.7%)	6 (4.3%)	.369
Jaw pain	15 (11.2%)	5 (3.5%)	.015
Back pain	8 (6.0%)	11 (7.8%)	.549
Dyspnea	50 (37.3%)	46 (32.6%)	.415
Syncope	1 (0.7%)	5 (3.5%)	.122
Dizziness	12 (9.0%)	12 (8.5%)	.896
Diaphoresis	19 (14.2%)	27 (19.1%)	.270
Palpitations	6 (4.5%)	4 (2.8%)	.468
Nausea or vomiting	30 (22.4%)	28 (19.9%)	.607
Other symptoms	4 (3.0%)	9 (6.4%)	.184

Table 3. Comparison of outcomes between patients admitted in 2019 and 2020.

Outcomes	March through July 2020 (n = 74)	August through December 2020 (n = 67)	*P*-value
Death	6 (4.5%)	3 (2.1%)	.274
Cardiac arrest	8 (6.0%)	8 (5.7%)	.825
VF	5 (3.7%)	6 (4.0%)	.916
Pulseless VT	1 (0.7%)	0 (0.0%)	.304
PEA	2 (1.4%)	1 (0.7%)	.532
Asystole	3 (2.2%)	1 (0.7%)	.290
Arrhythmias	20 (14.9%)	20 (14.2%)	.862
Heart block	3 (2.2%)	3 (2.1%)	950
Sinus bradycardia	5 (3.7%)	6 (4.3%)	.825
Non-sustained VT	4 (3.0%)	6 (4.3%)	.574
Sustained VT	1 (0.7%)	2 (1.4%)	.592
New onset AF/atrial flutter	5 (3.7%)	5 (3.5%)	.935
Other arrhythmias	1 (0.7%)	1 (0.7%)	.971
ICU admission	-	10 (7.1%)	.892
Intravenous vasopressors	1 (0.7%)	7 (5.0%)	.922
Mechanical intervention	7 (5.2%)	8 (5.7%)	.870
IABP	3 (2.2%)	0 (0.0%)	.074
Temporary pacemaker implantation	1 (0.7%)	3 (2.1%0	.339
Permanent pacemaker implantation	2 (1.5%)	0 (0.0%)	.144
Acute renal failure	25 (18.7%)	21 (14.9%)	.403
EF	46.9 ± 13.5	45.2 ± 14.8	.348
Drop in EF from baseline	10.9 ± 12.3	9.1 ± 11.13	.475
Hospital LOS	3.5 ± 2.3	3.9 ± 3.2	.224
Cardiac catheterization	128 (95.5%)	133 (94.3%)	.652
PCI	105 (78.4%)	110 (78.0%)	.945
Referred for CABG	4 (3.0%)	12 (8.5%)	.050
Medical treatment alone	25 (18.7%)	19 (13.5%)	.241

AF = atrial fibrillation; CABG = coronary artery bypass graft; EF = ejection fraction; IABP = intra-aortic balloon pump; LOS = length of stay; PCI = percutaneous coronary intervention; PEA = pulseless electrical activity; VF = ventricular fibrillation; VT = ventricular tachycardia

Discussion

Our study showed that there were no significant differences in the mortality, cardiac arrest, arrhythmia, drop in EF, acute renal failure, and ICU admissions of MI encounters before and during the pandemic, although referrals for CABG surgery were more in 2020 than in 2019. There was a decrease in the rate of cardiac catheterization and an increase in the rate of medical treatment alone in the first 5 months of the pandemic compared with the last 5 months in 2020.

A statement from the Society for Cardiovascular Angiography and Interventions, the American College of Cardiology, and the American College of Emergency Physicians recommended PCI as a standard of care for STEMI, including for COVID-19 confirmed or probable patients. It is also recommended to do complete revascularization in the same settings for non-culprit lesions to minimize the catheterization staff's recurrent exposure in a staged procedure.[9,10] For patients with NSTEMI and confirmed COVID-19, type I MI due to plaque rupture is possible. However, it is still possible to have myocarditis, stress cardiomyopathy, coronary spasm, left ventricular strain, right heart failure, or type II MI due to severe illness. Therefore, patients who are COVID-19 positive are recommended to be managed medically and only taken for revascularization in the presence of high-risk clinical features (Global Registry of Acute Coronary Events score >140) or hemodynamic instability.[9] Conversely, patients admitted with NSTEMI who are not confirmed to have COVID-19 should continue to receive the standard medical therapy with early revascularization as clinically indicated.[11]

Our study, which compared the first 10 months of the pandemic with the equivalent period in 2019, showed a higher overall rate of CABG surgery referral during the pandemic. Referrals for CABG surgery in our hospital are typically made to a tertiary hospital that was included in a study by Salenger et al in Maryland.[12] Although they reported a 54% slowdown in cardiac surgeries during the first month of the pandemic (March to April 2020) compared with baseline, they expected an upcoming surge of cardiac surgeries starting from June or July 2020 to clear the backlog. Furthermore, their reported decline in the rate of CABG surgeries was mainly due to deferral of elective procedures as opposed to urgent cases.[12]

Our study showed lower rates of cardiac catheterizations in the first 5 months of the pandemic compared with the following 5 months in 2020. When we evaluated the patients who did not undergo cardiac catheterizations, we found 2 patients with STEMI (1 patient refused cardiac catheterization, and the other patient did not undergo cardiac catheterization due to advanced age, multiple comorbidities, and a code status of do not resuscitate). In the NSTEMI patients, cardiac catheterizations were deferred in 12 cases for different reasons, including patients' preferences (half of the cases), difficult revascularization based on previous films review, undergoing evaluation by stress test, or medical condition (age and comorbidities). Two patients in our study tested positive for COVID-19 and both underwent cardiac catheterization along with revascularization. The increased rate of patients refusing cardiac catheterization during the pandemic could be due to fear from contracting COVID-19 infection in the hospital. The increase in the rates of NSVT in patients who presented

Table 4. Comparison of outcomes between patients admitted in March through July and August through December 2020 study period.

Outcomes	March through July 2020 (n = 74)	August through December 2020 (n = 67)	*P*-value
Death	1 (1.4%)	2 (3.0%)	.502
Cardiac arrest	4 (5.4%)	4 (6.0%)	.885
VF	3 (4.1%)	3 (4.5%)	.901
Pulseless VT	0 (0.0%)	0 (0.0%)	-
PEA	1 (1.4%)	0 (0.0%)	-
Asystole	0 (0.0%)	1 (1.5%)	.340
Arrhythmias	14 (18.9%)	6 (9.0%)	.090
Heart block	1 (1.4%)	2 (3.0%)	.502
Sinus bradycardia	5 (6.8%)	1 (1.5%)	.112
Non-sustained VT	6 (8.1%)	0 (0.0%)	.017
Sustained VT	2 (2.7%)	0 (0.0%)	.175
New onset AF/atrial flutter	3 (4.1%)	2 (3.0%)	.732
Other arrhythmias	0 (0.0%)	1 (1.5%)	.292
ICU admission	4 (5.4%)	6 (9.0%)	.412
Intravenous vasopressors	4 (5.4%)	3 (4.5%)	.800
Mechanical intervention	4 (5.4%)	4 (6.0%)	.885
IABP	0 (0.0%)	0 (0.0%)	-
Temporary pacemaker implantation	2 (2.7%)	1 (1.4%)	.619
Permanent pacemaker implantation	0 (0.0%)	0 (0.0%)	-
Acute renal failure	13 (17.3%)	8 (11.6%)	.349
EF	43.5 ± 15.1%	47.1 ± 14.2	.154
Drop in EF from baseline	10.9 ± 12.6	7.6 ± 10.1	.223
Hospital LOS	4.1 ± 3.8	3.8 ± 2.5	.676
STEMI	32 (43.2%)	32 (47.8%)	.591
NSTEMI	42 (56.8%)	35 (52.2%)	.591
Cardiac catheterization	67 (90.5%)	66 (98.5%)	.041
PCI	53 (71.6%)	57 (85.1%)	.054
Referred for CABG	7 (9.5%)	5 (7.5%)	.671
Medical treatment alone	14 (18.9%)	5 (7.5%)	.047

AF = atrial fibrillation; CABG = coronary artery bypass graft; EF = ejection fraction; IABP = intra-aortic balloon pump; LOS = length of stay; NSTEMI = non-ST-elevation myocardial infarction; PCI = percutaneous coronary intervention; PEA = pulseless electrical activity; STEMI = ST-elevation myocardial infarction; VF = ventricular fibrillation; VT = ventricular tachycardia

early in the pandemic could be due to the lower rates of revascularization in that group.[13]

Our study did not show lower rates of MI admissions during most of the months during the pandemic compared with equivalent months in the year before. However, a pooled analysis by Singh et al including 38 studies (22 studies were from Europe, 8 from the U.S., 3 from China, 2 from the UK, and 1 each from Canada and Australia) comparing a total of 161,663 cases of acute coronary syndrome (ACS) before the pandemic period with 84,947 patients during the pandemic showed a 27.3% reduction in ACS-related hospitalizations in total, including a 23.5% reduction in the U.S.[14]

Our study showed a decrease in cardiac catheterizations early during the pandemic (the first 5 months) along with an increase in pursuing medical treatment alone, which was also noted in the Primary Angioplasty for STEMI during COVID-19 Pandemic (ISACS-STEMI COVID-19) registry from 77 centers in 18 countries. The purpose of the registry was to estimate the effect of the pandemic on the treatments and outcomes of patients with STEMI treated by PCI. It showed a 19% reduction of PCI procedures and a delay to treatment, which could be a reason for increased mortality during the pandemic.[15]

The delay in seeking care for patients with MI may lead to worse prognosis in general. Baldi et al showed that the pandemic time (first 2 months) in Italy was associated with increased incidence of out-of-hospital cardiac arrest (OHCA) as the incidence increased by 52% compared with the equivalent period in 2019. However, patients with a confirmed COVID-19 diagnosis constituted 74% of this increase.[16] A similar study by Marijon et al in France found that OHCA incidence doubled in the first 6 weeks of the pandemic, and patients with COVID-19 constituted only 33% of this excess. They also noted a rise in median emergency medical services response time from 9.4 to 10.4 minutes, along with reduced survival rates.[17] An increase in the number of mechanical complications (mitral regurgitation and ventricular rupture) of acute MI was also noted in 2 university hospitals in Taiwan in the first 5 weeks of the pandemic compared with the period from January 2015 to December 2019.[18] The increase in mechanical complications of MI could be due to late hospital arrival due to fear of infection, late diagnosis due to misinterpretation with COVID-19 presentations, and late or deferred revascularization.[19]

Study Limitations

The main limitations of our study include the following: First, it was single-center study, and the urban population in Baltimore could have different characteristics than other areas, which can affect the dynamics of hospital presentation. The percentage of beds occupied by COVID-19 patients could also have altered the presentation of MI patients at certain regions. These regional changes could explain some of the inconsistencies in data from the single-center study vs the larger registry findings during the pandemic. Second, the characteristics of our patient population were not matched due to the relatively small sample. Third, our study did not describe the techniques of the performed PCI, such as the rates of aspiration thrombectomy, as these data were not available and extracted for all included patients. Fourth, our study was a descriptive study and did not find clear causes behind the increase in CABG surgery referrals during the pandemic. Our analysis reflects how public health emergencies can indirectly impact the management of unrelated health conditions. Multicenter studies on a large sample might help confirm these findings and generalize them.

Conclusion

In conclusion, the outcomes MI during the pandemic were not different in our hospital compared with an equivalent time from the prior year, although the referrals for CABG surgery were higher. The first 5 months of the pandemic were associated with a decrease in pursuing cardiac catheterization along with an increase in medical treatment alone compared with the following 5 months. ■

Disclosure: The authors have completed and returned the ICMJE Form for Disclosure of Potential Conflicts of Interest. The authors report no conflicts of interest regarding the content herein.

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