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Research Article

Differences in ST-segment Elevation Myocardial Infarction (STEMI) presentation and outcomes between 2019-2021 related to COVID-19

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Abstract

Background and Aims: COVID-19 accounted for 12.2% deaths in the United States between March 2020 and October 2021, while heart disease deaths increased by 4.1% from 2019 to 2020. Our study analyses the differences in STEMI presentation from 2019-2021 and the potential outcome differences for years related to the COVID pandemic.

Materials and Methods: A five-site retrospective study included 1001 STEMI-activated patients from January 2019 to December 2021. Patient demographics, risk factors, details of presentation and rationale for cath-lab activation were obtained as presentation details. Discharge status, intraprocedural death, major bleeding requiring transfusion, CABG status and indication, and time variables were obtained to evaluate outcomes.

Results: For 1001 STEMI-activated patients, risk factors were cerebrovascular accident (CVA), for 2019 versus 2020. New onset angina was significant in 2019 and 2021 versus 2020. Worsening angina was significant in 2019 versus 2020 as rationale. Patients were similarly discharged alive and required similar transfusion. CABG indications were similar, with no between-year differences. There were not differences in time variables for patients Discharged-alive but for patients Discharged-deceased, there was increased procedure to discharge and length of stay (LOS) for 2021 versus 2020. Also, patients Discharged-alive in all three years had shorter mean door-to-balloon (DTB) times than patients who were discharged-deceased in 2021.

Discussion: For COVID-relevant years 2019-2021, patients had similar backgrounds for a STEMI-activated presentation. Patients were 1.84 times more likely to have history of CVA when they presented in 2019 versus 2020. New onset angina was higher in 2019 and 2021 and worsening angina was significant in 2019. Therefore, 2019 seemed to be more representative of typical angina presentation, compared to COVID peak 2020 and afterward to 2021. There was no increased rate of deaths attributed to STEMI hospitalization indicating that patients may have delayed to seek care, possibly attributed to the impact of the COVID lockdown or died at home related to cardiac event rather than seek medical care. For secondary outcomes, transfusion was equally likely. There were delays in procedure to discharge, LOS, and DTB times for 2021 versus 2020, which may be related to overall resource limitations.

Keywords: stemi; covid; outcomes; pandemic; cva

Introduction

Cardiac outcomes are important to consider in a COVID-19 pandemic era. COVID-19 accounted for 12.2% of all deaths between March 2020 and October 2021. This made the novel virus the third leading cause of death behind heart disease and cancer during this period.[1] Concomitant with COVID-19-attributed mortality, heart disease deaths also increased by 4.1% from 2019 to 2020.[2] Patients who had pre-existing cardiovascular disease had more than a 10-fold increase in mortality compared to those without

cardiovascular comorbidities.[3,4] In part attributing to death rates, it was found that treatment complications were higher among secondary cardiac injury in COVID-19-positive patients.[4] This is considered alongside the other important COVID-19 complications of respiratory distress, acute kidney injury, and coagulation disorders.[1-4]

Arrhythmias are commonly seen in patients admitted after COVID-19 infection. Unspecified arrhythmias at a weighted mean average of 9.3%, followed by supraventricular, 8.5%, and ventricular arrhythmias, 2.7%, were predominant.[5] New onset heart failure has been found in as much as a third of patients admitted for COVID-19.[6] In addition, clotting disorders notably venous thromboembolism, while commonly found in any critical illness, were especially true in COVID-19 cases, and disseminated intravascular coagulation (DIC) was associated in 71.4% of patients who died of COVID-19.[7]

Elevated levels of CRP, fibrinogen, d-dimer, factor VIII, vWF, and protein C, are associated with more severe forms of COVID-19 infection. B-type natriuretic peptide (BNP) and cardiac troponin I (cTnI) trended to be higher in those with COVID-19-positive infection, suggesting a possible increased risk for myocarditis.[8] There are several case studies elaborating on myocarditis and COVID-19. [9-11]

COVID-19 has a direct and indirect effect on the cardiovascular system. Directly, SARS-CoV-2 incorporates into cells by way of the ACE type 2 (ACE-2) receptor, which is also found in 7.5% of myocardial cells. The COVID-19 spike protein is activated and internalized by the type 2 transmembrane protease receptor after binding to ACE-2.[12] The effect is subsequent hyperstimulation of the ACE-2 pathway and inflammation followed by fibrosis.[13] Indirectly, this cytokine storm can incite a dysregulated immune response including destabilizing cardiac plaques that rupture and lead to coronary artery thrombosis or spontaneous coronary artery dissection. Also contributory is an associated oxygen demand-perfusion mismatch. Downstream activation of RAAS or inflamed myocardium can alter resting membrane potentials leading to left ventricular dysfunction and acidosis with reduced perfusion. Resultant arrhythmias can lead to complications.[12]

Given what is known now regarding the virus, we desired to elaborate clinically. The study aims to compare a STEMI-presenting background of patients between the years 2019 and 2021, observe outcome details in pre-, peri-, and post-pandemic lockdown periods, and consider time and quality measures. We made several hypotheses such as that the background comorbidities of patients would be similar between the observed years, but that severity of presentation would be worse for patients presenting in 2020, during the COVID lockdown period. We suspected that patients presented later in a cardiac event due to fear of hospitalization or lockdown protocol and therefore with worser cardiac severity.[14] We hypothesized that time from presentation to procedure would be longer in 2020 as well as the length of hospitalization. We predicted that the mortality rate would be higher in 2020 when presenting as a STEMI alert.

Materials and Methods

The study was approved by Wright State University Institutional Review Board (IRB) and entailed an observational study of 1001 patients who were STEMI-activated between 1 January 2019 and 31 December 2021 at 5 hospital sites in Southwest Ohio. Subjects were STEMI-activated in COVID-significant years 2019- 2021. All patients were aged 18 years or older and STEMI-activated upon presentation.

Seven categories of interest including: baseline characteristics, details of presentation, procedure details, diagnostic values, rationale, time variables, and outcomes were obtained and evaluated to determine if there were significant differences in various patient characteristics between the three years. These details were gathered from the Epic electronic medical record (EMR) using the Microsoft SQL Server Manager [15] and from National Cardiovascular Data Registry (NCDR) for our institution.[16] SAS version 9.4 (SAS Institute, Inc., Cary, NC) and RStudio version 2022.07.1 (RStudio, Inc., Boston, MA) were used for all analyses. [17-18] A level of significance of $\alpha = 0.05$ was used throughout to assess statistical significance.

A first multinomial logistic regression was run for each of baseline characteristics with year (2019, 2020, and 2021) as the response variable and all variables of interest (age, gender, BMI, hypertension, dyslipidemia, diabetes mellitus, cerebrovascular disease, peripheral arterial disease, chronic lung disease, prior coronary artery bypass graft, tobacco use, currently on dialysis, heart failure, and heart failure newly diagnosed) as predictor variables. 2020 was used at the reference level since the comparisons of the other two years to 2020 are of primary interest. There fore the results are expressed in terms of whether there are significant differences or associations between the independent variables of interest in 2020 compared to 2019 and 2020 compared to 2021. This model predicts the odds of a patient presenting with the given baseline characteristic in 2019 or 2021 compared to 2020.

A second multinomial logistic regression was run for details of presentation, with year (2019, 2020, and 2021) as the response variable. Independent variables were included for out-of-hospital cardiac arrest (OOHCA), cardiac arrest at transfer, and inpatient cardiac arrest. This model predicts the odds of patient cardiac arrest presentation in 2019 or 2021 compared to 2020.

A third multinomial logistic regression was run for procedure details, with year (2019, 2020, and 2021) as the response variable. Independent variables were included for contrast volume and concomitant procedures performed. This model predicts the odds of patient procedure details in 2019 or 2021 to 2020.

A fourth multinomial logistic regression was run for diagnostic values, with year (2019, 2020, and 2021) as the response variable. Independent variables were included for systolic blood pressure, troponin T pre-procedure, creatinine pre-procedure, hemoglobin pre-procedure, creatinine post-procedure, and hemoglobin post-procedure. This model predicts the odds of patient presenting with given diagnostic values in 2019 or 2021 compared to 2020.

A fifth multinomial logistic regression was run for intervention rationale, with year (2019, 2020, and 2021) as the response variable. Independent variables were included for OOHCA, cardiac arrest at transfer, and inpatient cardiac arrest. This model predicts the odds of given rationale in 2019 or 2021 compared to 2020.

A sixth multinomial logistic regression was run for outcomes, with year (2019, 2020, and 2021) as the response variable. Independent variables were included for discharge status and packed red blood cell transfusion. Given that a disproportionate number of patients were discharged as alive, alive and deceased patients were divided into distinct groups for accurate statistical analysis. This model predicts the odds of patients with a given outcome in 2019 or 2021 compared to 2020. These same divisions for Discharged-alive, Discharged-deceased were used for time variables.

Because the number of patients who were COVID-positive was significantly limited in our data set (N=21), it ultimately was not possible to run a meaningful statistical analysis. For example, in 2020 there were 59 female patients who tested negative for COVID, which represents 35.33% of all patients in 2020 who tested negative for COVID. This indicates highly skewed data due to the limited size of our COVID-tested sample. We could not include 2019 data given the COVID test became available in February 2020.[13].

Results

A total of 1001 patients who were STEMI activated were included in the study: 336 in 2019, 317 in 2020, and 348 in 2021. This included all patients who were admitted as adults 18 years and older at our institution and within facility STEMI-activation, where duplicate patients were removed from the sample. The average age of presentation was 63.5 years old, body mass index (BMI) was 30.2 kg/m^2, and preprocedural ejection fraction was 51.3%. Year

of presentation was the independent predictor for outcomes in our model with 2019 as the pre-COVID lockdown period, 2020 as the peri-COVID lockdown period, and 2021 as the post-COVID lockdown period.

Table 1 shows data results from descriptive statistics of STEMI presentation in pre, peri and post COVID lockdown. We saw no association in the following descriptive statistics of STEMI presentation during the pre, peri and post COVID lockdown period 2019-2021. In an analysis of demographics including age and BMI we saw no association. This is also true for risk factors including male gender, hypertension (HTN), dyslipidemia, diabetes mellitus (DM), peripheral artery disease (PAD), chronic lung disease, prior coronary artery bypass graft (CABG), tobacco use, dialysis patients, history of congestive heart failure (CHF) or newly diagnosed CHF.[19] We also saw no significant associations in the details of presentation including OOHCA, cardiac arrest at transfer, and inpatient cardiac arrest. All the p-values are greater than 0.05 therefore, there was not sufficient evidence to suggest there are any significant relationships between these variables of interest and the year.

Table 1. Descriptive statistics of STEMI presentation, 2019-2021.

Variable	Overall (% or Mean ±SD)	2020 (% or Mean ±SD)	2019 (% or Mean ±SD)	OR	p-value, 95% CI	2021 (% or Mean ±SD)	OR	p-value, 95% CI
Demographics								
Age	1001 (63.5±12.6)	317 (63.8±12.1)	336 (63.8±12.7)	1.00	0.56 (0.99, 1.02)	348 (63.0±13.0)	1.00	0.96 (.99, 1.01)
BMI	983 (30.2±6.5)	312 (29.8±6.3)	334 (30.1±6.5)	1.01	0.31 (0.99, 1.04)	337 (30.6±6.7)	1.02	0.07 (0.99, 1.05)
Risk factor								
Male Gender	689 (68.8)	212 (66.9)	232 (69.05)	0.89	0.52 (0.63, 1.26)	245 (70.4)	0.81	0.24 (0.57, 1.15)
Hypertension	755 (75.4)	250 (78.9)	244 (72.6)	0.72	0.12 (0.47, 1.09)	261 (75.0)	0.78	0.25 (0.51, 1.19)
Dyslipidemia	735 (73.5)	236 (74.45)	242 (72.0)	0.92	0.70 (0.61, 1.39)	257 (74.1)	1.10	0.66 (0.73, 1.66)
Diabetes Mellitus	318 (31.8)	104 (32.8)	105 (31.25)	0.97	0.88 (0.67, 1.4)	109 (31.3)	0.99	0.98 (0.69, 1.43)
CVA	120 (12.0)	35 (11.0)	53 (15.8)	**1.84**	**<0.05** (1.12,3.02)	32 (9.2)	0.90	0.71 (0.53, 1.55)
PAD	70 (7.0)	29 (9.15)	23 (6.85)	0.76	0.39 (0.41, 1.41)	18 (5.2)	0.54	0.07 (0.28, 1.05)
Chronic lung disease	190 (19.0)	59 (18.6)	66 (19.6)	1.26	0.29 (0.82, 1.93)	65 (18.7)	1.22	0.36 (0.8, 1.88)
Prior CABG	63 (6.3)	22 (6.9)	21 (6.3)	1.18	0.64 (0.6, 2.29)	20 (5.8)	0.89	0.74 (0.45, 1.76)
Tobacco use	650 (65.5)	210 (66.9)	217 (65.4)	0.88	0.49 (0.62, 1.26)	223 (64.3)	0.86	0.41 (0.61, 1.23)
Dialysis patient	17(1.7)	6 (1.9)	5 (1.5)	1.10	0.88 (0.3, 3.99)	6 (1.7)	1.07	0.91 (0.31, 3.64)
History CHF	178 (17.8)	65 (20.5)	52 (15.5)	0.58	0.06 (0.33, 1.02)	61 (17.5)	1.06	0.82 (0.63, 1.81)
Newly diagnosed CHF	59 (5.9)	22 (6.9)	20 (5.95)	1.28	0.56 (0.56, 2.91)	17 (4.9)	0.62	0.25 (0.28, 1.4)
Details of presentation								
OOHA	55 (5.5)	22 (6.9)	16 (4.8)	0.67	0.27 (0.33, 1.36)	17 (4.9)	0.65	0.22 (0.33, 1.30)
Cardiac arrest at transfer	21 (2.1)	6 (1.9)	9 (2.7)	1.66	0.36 (0.57, 4.88)	6 (1.7)	1.05	0.93 (0.33, 3.38)
Within hospital cardiac arrest	61 (6.1)	21 (6.6)	15 (4.5)	0.72	0.35 (0.36, 1.44)	25 (7.2)	1.20	0.56 (0.64, 2.24)
Rationale								
New onset angina	164 (16.4)	46 (14.5)	100 (29.8)	**2.23**	**<0.05** (1.42,3.50)	18 (5.2)	**0.33**	**<0.05** (0.17,0.62)
Worsening angina	68 (6.8)	18 (5.7)	38 (11.3)	**2.72**	**<0.05** (1.49,4.96)	12 (3.45)	0.50	0.07 (0.23, 1.05)
Resuscitated	65 (6.5)	24 (7.6)	23 (6.85)	0.87	0.74 (0.36, 2.06)	18 (5.2)	0.78	0.58 (0.32, 1.89)
Cardiac arrhythmia	52 (5.2)	17 (5.4)	22 (6.55)	1.17	0.76 (0.46, 2.98)	13 (3.7)	0.77	0.62 (0.28, 2.14)
Suspected CAD	270 (27.0)	82 (25.9)	132 (39.3)	1.43	0.08 (0.96, 2.12)	56 (16.1)	0.69	0.09 (0.45, 1.06)
Syncope	7 (0.7)	1 (0.3)	4 (1.2)	3.85	0.25 (0.39,38.15)	2 (0.6)	1.71	0.66 (0.15, 19.37
Cardiovascular Instability	953 (95.2)	301 (94.95)	320 (95.2)	1.18	0.69 (0.53, 2.6)	332 (95.4)	1.38	0.42 (0.64, 2.96)
STEMI or STEMI Equivalent on First EKG	786 (81.0)	243 (79.15)	270 (82.8)	1.19	0.41 (0.79, 1.79)	273 (81.0)	1.18	0.40 (0.8, 1.76)

Definitions: BMI, body mass index by kg/m2. CABG, coronary artery bypass graft. CAD, coronary artery disease. CVA, cerebrovascular accidence, defined as stroke or transient ischemia attack. CHF, congestive heart failure. EMS, emergency medical services. LVEF, left ventricular ejection fraction. OOHA, out of hospital arrest. PVD, peripheral vascular disease. STEMI, ST elevation myocardial infarction.

There was strong evidence to suggest a significant association between a history of cerebrovascular disease (CVA) and STEMI presentation during 2019 compared to 2020 (OR 1.84, 95% CI 1.12-3.02, p=0.0138). The odds were 84% higher for patients with a background history of CVA who presented with STEMI in 2019 than 2020.

Analysis of the rationale for STEMI presentation compared patients' presentation to the hospital including new onset angina, worsening angina, resuscitation, cardiac arrhythmia, suspected coronary artery disease (CAD), syncope, cardiovascular instability and STEMI or STEMI equivalent on first EKG, with year of presentation at the independent predictor. New onset angina and worsening angina were both found to be statistically significant rationales for 2019 compared to 2020 (OR 2.23, 95% CI of 1.42-3.50, p = 0.0005). The odds were 123% higher for a patient to present as a STEMI-activation with new onset angina in 2019 than 2020. The opposite was true for 2021 in which new onset angina 2021 vs 2020 (OR 0.33, 95% CI 0.17-0.62, p = 0.0005) was 67% lower for patients in 2021. Worsening angina was of significance for 2019 vs 2020 (OR 2.72, 95% CI 1.49- 4.96, p = 0.0011) when presenting with STEMI, that is, an odds of 172% for worsening angina in 2019 compared to 2020. No other significant associations were detected in regard to rationale for presentation.

Table 2 compares outcome details as well as time variables in the discharge status of both alive and deceased patients. Details of discharged-alive patients included hospice care, intraprocedural death, packed red blood cell (pRBC) transfusion, transfusion during PCI, emergency CABG, and CABG indications including PCI/CABG hybrid, PCI failure, recommended following LHC and PCI complications. Amongst details including discharge status and need for pRBC transfusion, all p-values are greater than 0.05, therefore, there is not sufficient evidence to suggest significant relationships between these variables of interest and the year.

Table 2. Outcomes and time variables for STEMI activation, 2019-2021.

Outcomes details	Overall N(%)	2020 N(%)	2019 N(%)	OR	p-value,95% CI	2021 N(%)	OR	p-value,95% CI
Discharged-Alive	952 (95.1)	301 (94.95)	320 (95.2)	0.93	0.84 (0.46,1.9)	331 (95.1)	0.98	0.95 (0.48, 1.97)
Hospice care	13 (1.4)	5 (1.7)	3 (0.9)			5 (1.5)		
Intraprocedural death	6 (12.2)	2 (12.5)	3 (18.75)			1 (5.9)		
pRBC transfusion	64 (6.4)	20 (6.3)	24 (7.1)	1.10	0.77 (0.59,2.05)	20 (5.75)	0.91	0.77 (0.48, 1.73)
Transfusion during PCI	42 (65.6)	15 (75)	15 (62.5)			12 (60)		
CABG status-Emergency	11 (35.5)	5 (55.6)	2 (25)			4 (28.6)		
CABG indication								
PCI/CABG Hybrid	15 (48.4)	4 (44.4)	4 (50)			7 (50)		
PCI failure	9 (29.0)	2 (22.2)	2 (25)			5 (35.7)		
Recommended from LHC	5 (16.1)	1 (11.1)	2 (25)			2 (14.3)		
PCI complication	2 (6.5)	2 (22.2)	0			0		
Time variables	Overall (Mean SD	2020 (Mean SD)	2019 (Mean SD)	Estimate	p-value,95% CI	2021 (Mean SD)	Estimate	p-value, 95% CI
Discharged-Alive	256.9 (1086.2)	263.7 (913.9)	239.3 (1188.9)	-0.05	0.99(-0.31,0.2)	267.7 (1128.5)	-0.07	0.96 (-0.33, 0.18)
DTB (min)	290.2 (1181.9)	267.1 (921.3)	282.5 (1335.2)	-0.07	0.99 (-0.4,0.25)	318.7 (1236.7)	-0.08	0.98 (-0.41, 0.24)
Arrival to procedure (min)	86.7 (102.6)	85.0 (87.3)	85.5 (79.9)	0.04	1.00(-0.17,0.24)	89.4 (131.4)	-0.04	0.99 (-0.24, 0.16)
Procedure to discharge (hours	91.5 (107.6)	89.4 (91.8)	90.2 (85.3)	0.04	0.99(-0.16,0.24)	94.7 (136.6)	-0.02	0.99 (-0.21, 0.8)
LOS (hours)								
Discharged-Deceased								
DTB (min)	1281.8 (3064.4)	820.1 (2863.8)	368.9 (770.0)	0.18	0.99(-.96, 1.32)	2570.4 (4140.3)	1.05	0.08 (-0.07, 2.18)
Arrival to procedure (min)	1234.5 (2981.0)	749.1 (2775.1)	328.9 (750.9)	0.25	0.99(-1.18,1.69)	2543.7 (4004.3)	1.29	0.10 (-0.13, 2.7)
Procedure to discharge	78.5 (92.1)	57.7 (73.8)	68.0 (107.8)	-0.29	0.94(-1.18,0.6)	107.9 (89.4)	**1.05**	**<0.05**(0.17, 1.93)
(hours	99.1 (112.8)	70.2 (79.3)	73.5 (108.0)	-0.22	0.98(-1.09,0.65)	150.3 (130.5)	**1.04**	**<0.05**(0.19, 1.9)
LOS (hours)								

Abbreviations: CI, confidence interval. DTB, door to balloon. LOS, length of stay. LHC, left heart catheterization. pRBC, packed red blood cells.

Time variables for both Discharged-alive and Discharged-deceased patients included door to balloon time (DTB) time in minutes, arrival to procedure time in minutes, procedure to discharge time in hours, and length of stay (LOS) in hours. All time variables are reported as natural log secondary to data skewedness. Two results were found to be statistically significant. First, there was a significant mean difference in the natural log of procedure to discharge time for patients who were Discharged-deceased in 2021 and patients who were Discharged-deceased in 2020 ($p = 0.0085$). The estimated mean difference in the natural logs is 1.05 higher for patients who were Discharged-deceased in 2021. Second, there was also strong evidence to suggest a significant mean difference in the natural log of the LOS for patients who were Discharged-deceased in 2021 and patients who were Discharged-deceased in 2020 ($p = 0.0071$). The estimated mean difference in the natural logs is 1.04 higher for patients who were Discharged-deceased in 2021.

Regarding the COVID separate model of data, we wished to discuss in further detail for our site, similarly to Wang et al in their comparative meta-analysis in which COVID was noted to have a deep impact on therapeutic management and clinical outcomes[20] as well as Saad et al which observed in-hospital mortality for COVID-positive status patients compared to their COVID-negative or not-tested counterparts.[21] However there appear to be glaring differences between COVID-positive status and many of the time variables given the within chart limitation of COVID-positive sample N=21. Additional safety features or quarantining that needed to take place with COVID positive patients may have been a contributing factor.

Discussion

During the COVID lockdown, concern in medical communities was for those infected with the virus but also for the impact on other medical problems. Concern was that patients delayed presentation to the hospital to avoid COVID contact and hospital stays, admission, or care due to either fear of the virus or inability to seek normal routes of care. This is not a new phenomenon as it was well documented during the Ebola crisis when hospital utilization in areas dropped by 18%.[14] Concerns during the COVID pandemic were seen internationally, with late presentations for a variety of reasons including concern for contact with another person infected with the virus, hospital availability, and confusion regarding COVID protocols. [22-24]

The longer a STEMI remains undiagnosed and untreated, the more severe the presentation. Elements of the extensive Charleson Comorbidity Index which include age, history of cardiac event, heart failure, PVD, CVA, dementia, COPD, connective tissue disease, liver disease, peptic ulcer disease, liver disease, diabetes, CKD, solid tumor, leukemia, lymphoma, AIDS, COVID were used [19] as well as *new onset* designation of heart failure and hemodynamics for cardiogenic shock on arrival. We wished to determine if the designated COVID years were worse in severity compared to each other. Patients with a history of CVA presented 1.87 times more likely in 2019 compared to 2020, as an indicator that patients with co-morbidities either avoided medical care or sought alternative ways of treatment, such as not treating, during the COVID lockdown. They may have died at home due to another primary cause.

There was no difference in severity between 2019-2021. However, the indication for arrival did change. As noted, worsening angina and new onset angina were significant in 2019 compared to 2020-2021. Patients would have either more at-home cardiac events or deaths by delaying care.[25-26] Patients were less likely to present with worsening angina in 2020 and 2021 as the documented rationale for pursuit of cardiac catheterization. This may reflect a change in mental indicator of when to seek medical care that has changed in the aftermath of the COVID peak or the data collector may have annotated differently for later years.

No between-year differences in mortality were noted, but there were significant differences regarding increased length of time in procedure to discharge, LOS, and DTB times in 2021 compared to 2020.[27-30] Some notable difficulties with the COVID lockdown in 2020 had been limited physical resources as well as less staffing and hospital bed availability. The goal at the time was to decrease the number of admissions to avoid straining the PPE and other resources available for COVID and non-COVID patients. In the United States, there was increased mortality for all patients admitted

to hospitals, not limited to COVID-positive, supporting this concern.[31] A possible explanation for delay in DTB time, delay in procedure to discharge, and overall LOS is related to strain in healthcare resources and not in severity of presentation or patient-related variables.

Many limitations and methodological biases exist, mainly this is a retrospective observation for a database-driven study. Presentation and delay of presentation are inferences based on the apparent severity at presentation and the time of symptoms to arrival is not measured. The number of COVID-positive patients in this study were also significantly limited (N=21) in our EMR, which did not allow for a statistically significant analysis of outcomes given skewed values compared to the total sample (N=1001). A larger study, likely multicentered, would be better to evaluate outcomes in COVID-positive STEMI-activated patients.

Conclusion

In summary, history of CVA was a significant background of patients who were more likely to present overall. The literature supports that presentation of STEMI patients was delayed during the COVID pandemic while our data did not support a delay in presentation. We did see a change in new onset angina and worsening angina as typical STEMI presentation in 2019 compared to 2020-2021. This could represent patients presenting less often for new angina and worsening angina as a result of the COVID pandemic. There may be a change in mentality of patients when it is appropriate to seek medical attention, with new onset symptoms decreased in 2021. There was no change in outcomes based on mortality, although by time variables, increased LOS, intervention to discharge, and DTB in the 2021 may be related to overall resource limitations due to the COVID pandemic.

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Credit authorship contribution statement

The primary author contributed to the entirety of the IRB protocol, data collection, discussion with statisticians, creation of figures and tables, manuscript writing, and editing. Coauthors contributed in decreasing order to IRB protocol, data collection, discussion with statisticians, manuscript writing and editing. Our faculty advisor provided oversight for the project as a seasoned cardiologist. We wish to thank our statistician, Michael Bottomley, for his careful handling of the data and any changes we needed to make along the way, as medicine and statistics can be very different languages.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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