The Texas Heart Institute® Journal

Clinical Investigation

Recovery From the Impact of COVID-19 on Treatment Times and Clinical Outcomes of Patients With ST-Segment Elevation Myocardial Infarction: An Interim Analysis

Abdelrahman Ali, MD[1]; Thomas Schirmer, RN[2]; Francis J. Kiernan, MD[2]; Bryan Piccirillo, MD[2]; Joseph Ingrassia, MD[2]; Talhat Azemi, MD[2]; Immad Sadiq, MD[2]; Daniel B. Fram, MD[2]; Asad Rizvi, MD[2]; Saurabh Joshi, MD[2]; Jeffrey Mather, MS[3]; Raymond G. McKay, MD[2]

[1]Division of Hospital Medicine, Hartford Hospital, Hartford, Connecticut
[2]Division of Cardiology, Hartford Hospital, Hartford, Connecticut
[3]Division of Research Administration, Hartford Hospital, Hartford, Connecticut

Abstract

Background: Previous studies have documented a negative impact of the COVID-19 pandemic on emergent percutaneous treatment of patients with ST-segment elevation myocardial infarction (STEMI), but few have examined recovery of healthcare systems in restoring prepandemic STEMI care.

Methods: Retrospective analysis was performed of data from 789 patients with STEMI from a large tertiary medical center treated with percutaneous coronary intervention between January 1, 2019, and December 31, 2021.

Results: For patients with STEMI presenting to the emergency department, median time from door to balloon was 37 minutes in 2019, 53 minutes in 2020, and 48 minutes in 2021 ($P < .001$), whereas median time from first medical contact to device changed from 70 to 82 to 75 minutes, respectively ($P = .002$). Treatment time changes in 2020 and 2021 correlated with median emergency department evaluation time (30 to 41 to 22 minutes, respectively; $P = .001$) but not median catheterization laboratory revascularization time. For transfer patients, median time from first medical contact to device changed from 110 to 133 to 118 minutes, respectively ($P = .005$). In 2020 and 2021, patients with STEMI had greater late presentation ($P = .028$) and late mechanical complications ($P = .021$), with nonsignificant increases in yearly in-hospital mortality (3.6% to 5.2% to 6.4%; $P = .352$).

Conclusion: COVID-19 was associated with worsening STEMI treatment times and outcomes in 2020. Despite improving treatment times in 2021, in-hospital mortality had not decreased in the setting of a persistent increase in late patient presentation and associated STEMI complications.

Keywords: STEMI; COVID-19; percutaneous coronary intervention

Introduction

The COVID-19 pandemic has adversely affected healthcare systems worldwide, not only in the diagnosis and treatment of millions of people infected with SARS-CoV-2 but also in the disruption of routine medical care delivery for elective and emergent conditions. With respect to cardiovascular disease, a prominent example of the negative impact of the COVID-19 pandemic has been the documented effects on emergent percu-

Citation: Ali A, Schirmer T, Kiernan FJ, Piccirillo B, Ingrassia J, Azemi T, Sadiq I, Fram DB, Rizvi A, Joshi S, Mather J, McKay RG. Recovery from the impact of COVID-19 on treatment times and clinical outcomes of patients with ST-segment elevated myocardial infarction: an interim analysis. *Tex Heart Inst J*. 2023;50(2):e227919. doi:10.14503/THIJ-22-7919

Corresponding author: Abdelrahman Ali, MD, Division of Hospital Medicine, Hartford Hospital, 80 Seymour Street, Hartford, CT 06115 (abdelrahman.ali89@gmail.com)

taneous revascularization for patients with ST-segment elevation myocardial infarction (STEMI).[1-7] Apart from mortality related to COVID-19 disease and COVID-19 myocarditis that may masquerade as STEMI, the need for preprocedure patient assessment, virus testing, and patient triage may delay the normal rapid transport of patients with STEMI to a cardiac catheterization laboratory for urgent percutaneous coronary intervention (PCI). Delays in coronary revascularization, measured in minutes, may result in increased ischemic duration, resulting in larger infarct sizes with increased morbidity and mortality. Of equal importance, patient reluctance to seek emergency care because of fears of contracting the virus has resulted in patients receiving no treatment or seeking treatment after a long duration of symptom onset with decreased efficacy of urgent coronary recanalization.

Recognition of the deleterious impact of COVID-19 on STEMI care has necessitated that healthcare systems respond to this quality crisis by reorganizing resources, instituting new operational policies, and supporting public media campaigns to increase patient awareness about the need to seek emergency medical care. The purpose of the current study is to document the effect of COVID-19 on STEMI treatment times and outcomes in a tertiary care hospital with a large population of patients with STEMI, with an interim report on efforts to return nationally reported STEMI quality metrics to prepandemic levels.

Patients and Methods

Study Design and Setting

This retrospective, observational study was conducted at Hartford Hospital, an 890-bed tertiary care medical center in Hartford, Connecticut. The study was approved by the Hartford Hospital institutional review board, with waiver of the requirement to obtain informed consent.

Study Population and Definitions

Data from all consecutive patients with STEMI referred for primary PCI between January 1, 2019, and December 31, 2021, were analyzed. Patients were classified either as direct presenters, who presented directly or were transported from home to the emergency department (ED) by emergency medical services, or as transfer patients, who were initially diagnosed with STEMI at an outlying hospital and emergently transferred for PCI. Standard definitions of door-to-balloon (DTB) and first medical contact–to–device (FMC-D) times for STEMI direct presenters and FMC-D times for STEMI transfer patients were used. Late STEMI presentation was defined as hospitalization beginning more than 12 hours after symptom onset.

Abbreviations and Acronyms

DTB	door-to-balloon
ED	emergency department
FMC-D	first medical contact–to–device
IQR	interquartile range
PCI	percutaneous coronary intervention
STEMI	ST-segment elevation myocardial infarction

Statistical Analysis

Continuous variables are expressed as mean (SD) or median (IQR) and were compared using an analysis of variance or the Kruskal-Wallis test, respectively, followed by post hoc comparisons with Bonferroni corrections. Categorical variables were analyzed using the χ^2 test or Fisher exact test, as appropriate. All outcomes were considered significant at $P < .05$. The statistical analyses were performed with SPSS, version 21.0 (IBM Corporation).

Results

A total of 789 patients with STEMI underwent primary PCI between January 1, 2019, and December 31, 2021, including 251 patients in 2019 (125 direct presenters and 126 transfers), 271 patients in 2020 (133 direct presenters and 138 transfers), and 267 patients in 2021 (140 direct presenters and 127 transfers). The demographic and clinical characteristics for all 3 study groups are summarized in Table I. Patients in all calendar years were well matched with respect to baseline characteristics, cardiac risk factors, clinical comorbidities, and cardiac history, except for a higher incidence of peripheral vascular disease in the 2020 cohort. A total of 7 patients tested positive for COVID-19 illness during their STEMI hospitalization, with 4 patients in 2020 and 3 patients in 2021. A total of 16 transfer patients were initially treated with intravenous thrombolytic

TABLE I. Baseline Demographic and Clinical Characteristics

Characteristic	No. (%) of patients			*P* value[a]
	2019 (n = 251)	2020 (n = 271)	2021 (n = 267)	
Demographics				
Age, mean (SD) y	63.0 (12.3)	62.0 (12.2)	63.4 (12.7)	.404
Male, No. (%)	186 (74.1)	204 (75.3)	196 (73.4)	.882
BSA, mean (SD), m^2	1.99 (0.26)	2.00 (0.28)	1.99 (0.26)	.883
BMI, mean (SD), kg/m^2	32.2 (20.7)	33.6 (26.1)	33.1 (21.7)	.782
White, No. (%)	198 (78.9)	223 (82.3)	200 (74.9)	.112
Cardiac risk factors, No. (%)				
Diabetes	61 (24.3)	64 (23.6)	75 (28.1)	.441
Hypertension	171 (68.1)	179 (66.5)	165 (61.8)	.302
Hyperlipidemia	155 (61.8)	166 (61.3)	160 (59.9)	.906
Family history	43 (17.1)	55 (20.3)	38 (14.2)	.177
Smoking history	142 (56.6)	142 (52.4)	153 (57.3)	.468
Comorbidities, No. (%)				
COPD	13 (5.2)	15 (5.5)	17 (6.4)	.835
CVD	8 (3.2)	7 (2.6)	9 (3.4)	.857
PVD	11 (4.4)	32 (11.8)	12 (4.5)	.001[b]
History, No. (%)				
MI	29 (11.6)	33 (12.2)	27 (10.1)	.741
PCI	34 (13.5)	41 (15.1)	33 (12.4)	.644
CABG	6 (2.4)	8 (3.0)	8 (3.0)	.898
COVID-19 test result, No. (%)	0 (0.0)	4 (1.5)	3 (1.1)	.175

BMI, body mass index; BSA, body surface area; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease.

[a] $P \leq .05$ is considered significant.
[b] $P = .006$ for 2019 vs 2020; $P = .006$ for 2020 vs 2021.

therapy before transfer for urgent PCI, with 4 patients in 2019, 4 patients in 2020, and 8 patients in 2021.

STEMI Treatment Times

For direct presenters, median DTB time increased from 37 minutes (IQR, 25-54 minutes) in 2019 to 53 minutes (IQR, 36-73 minutes) in 2020 and then decreased to 48 minutes (IQR, 35-59 minutes) in 2021 ($P < .001$; $P < .001$ for 2019 vs 2020). Similarly, median FMC-D time increased from 70 minutes (IQR, 57.5-85 minutes) in 2019 to 82 minutes (IQR, 66-93 minutes) in 2020 and then decreased to 75 minutes (IQR, 64-86 minutes) in 2021 ($P = .002$; $P = .001$ for 2019 vs 2020). Although decreases in DTB and FMC-D times between 2020 and 2021 were not significant in post hoc comparisons, increases in 2020 treatment times followed by subsequent decreases in 2021 were directly related to median ED evaluation time (30 minutes in 2019, 41 minutes in 2020, 22 minutes in 2021; $P < .001$) and not to median time of coronary revascularization after transfer to the cardiac catheterization laboratory.

For transfer patients, the median FMC-D time increased from 110 minutes (IQR, 96-145 minutes) in 2019 to 133 minutes (IQR, 109.5-163 minutes) in 2020 and then decreased to 118 minutes (IQR, 102-143 minutes) in 2021 ($P = .005$; $P = .004$ for 2019 vs 2020). Treatment times are summarized in Table II and illustrated in Figures 1 and 2.

STEMI In-Hospital Mortality

Observed in-hospital mortality increased from 3.6% in 2019 to 5.2% in 2020 and 6.4% in 2021 ($P = .352$). Death occurred secondary to COVID-19 illness in 1

TABLE II. Median STEMI Treatment Times[a]

	2019 (n = 251)	2020 (n = 271)	2021 (n = 267)	*P* value
STEMI type, No. (%)				
Direct presentation	125 (49.8)	133 (49.1)	140 (52.4)	.716
Transfer	126 (50.2)	138 (50.9)	127 (47.6)	
Direct presentation times, median (IQR), min				
DTB	37 (25-54)	53 (36-73)	48 (35-59)	<.001[b]
FMC-D	70 (57.5-85)	82 (66-93)	75 (64-86)	.002[c]
Emergency department	30 (14-49.5)	41 (29-62)	22 (12-35)	.001[d]
Catheter laboratory revascularization	16 (12-22)	17 (12-27)	23 (19-29)	<.001[e]
Transfer times, median (IQR), min				
FMC-D	110 (96-145)	133 (109.5-163)	118 (102-143)	.005[f]

DTB, door-to-balloon; FMC-D, first medical contact–to–device; STEMI, ST-segment elevation myocardial infarction.

[a] $P \leq .05$ is considered significant.
[b] $P < .001$ for 2019 vs 2020; $P < .001$ for 2019 vs 2021.
[c] $P = .001$ for 2019 vs 2020.
[d] $P < .001$ for 2019 vs 2020; $P < .028$ for 2019 vs 2021; $P < .001$ for 2020 vs 2021.
[e] $P < .001$ for 2019 vs 2021; $P < .001$ for 2020 vs 2021.
[f] $P = .004$ for 2019 vs 2020.

patient in 2020; there were no COVID-19 deaths in 2019 and 2021 ($P = .384$). Patients in 2020 and 2021 had the highest rates of late presentation ($P = .028$; $P = .036$ for 2019 vs 2021) and late mechanical complications ($P = .021$). Four patients in 2020 died from late mechanical complications, with ventricular septal rupture in 1 patient, free-wall rupture in 2 patients, and ruptured papillary muscle in 1 patient; no mechanical complications were observed in 2019 and 2021. In addition, 2020 and 2021 rates of preprocedure cardiac arrest and the 2020 rate of presentation with cardiogenic shock increased compared to 2019 rates, although these differences were not statistically significant. Table III lists the mortality rates and underlying clinical risk factors for patients during the 3 time periods.

Discussion

This study provides an interim analysis of the impact of COVID-19 on STEMI treatment times and clinical outcomes at a tertiary care center with a high volume of patients undergoing PCI for STEMI. The main results are as follows: (1) compared with 2019, STEMI volume increased in 2020 and 2021; (2) efficiency metrics, such as DTB time and FMC-D time for direct presenters and FMC-D time for transfer patients, all significantly worsened in 2020 and then improved toward prepandemic levels in 2021; (3) changes in DTB and FMC-D times for direct presenters in 2020 and 2021 were primarily related to the time of ED evaluation before transfer to the cardiac catheterization laboratory for intervention; (4) patients with STEMI in 2020 and 2021 had higher levels of late presentation, preprocedure cardiac arrest, preprocedure cardiogenic shock, and late mechanical complications; and (5) despite improving treatment times in 2021, observed in-hospital mortality has not decreased in the setting of a persistent increase in late patient presentation and associated STEMI complications.

Impact on STEMI Volumes

The first case of COVID-19 in Connecticut was diagnosed on March 6, 2020, and "Stay Safe, Stay Home" lockdown orders were issued on March 24, 2020.[8] Subsequent dramatic increases in COVID-19 cases, hospitalizations, and deaths peaked in April 2020 and again in January 2021. An early decrease was reported in STEMI activations by 38% during March 2020.[9] This early decrease was offset by increasing STEMI volume through 2020 and a persistent increase in 2021.

Several reports from healthcare systems have demonstrated different data regarding the rates of admission and PCI use for patients presenting with STEMI, especially early during the pandemic.[10-16] In a study by Wilson et al[11] from a single center in the United Kingdom, weekly PCI referrals decreased by 42.8% and STEMI presentations by 53% in the early phases of the pandem-

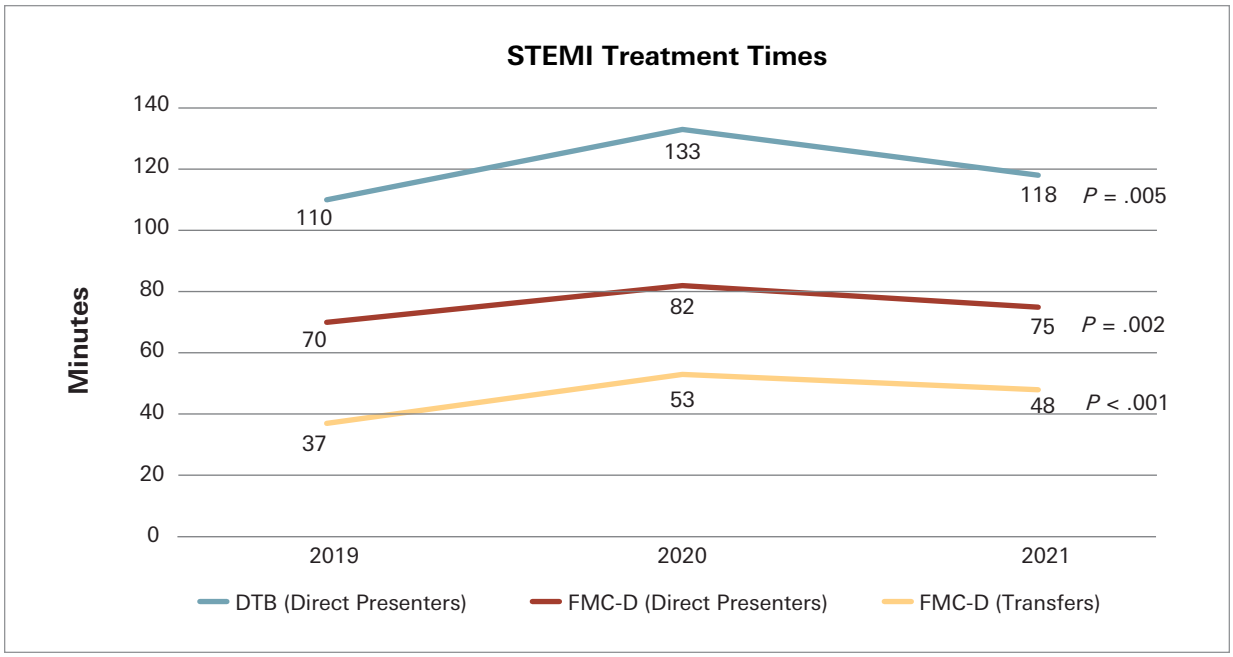

Fig. 1 Graph shows the DTB and FMC-D times for direct presenters and median FMC-D times for transfer patients for 2019, 2020, and 2021. $P \leq .05$ is considered significant.

DTB, door-to-balloon; FMC-D, first medical contact–to–device; STEMI, ST-segment elevation myocardial infarction.

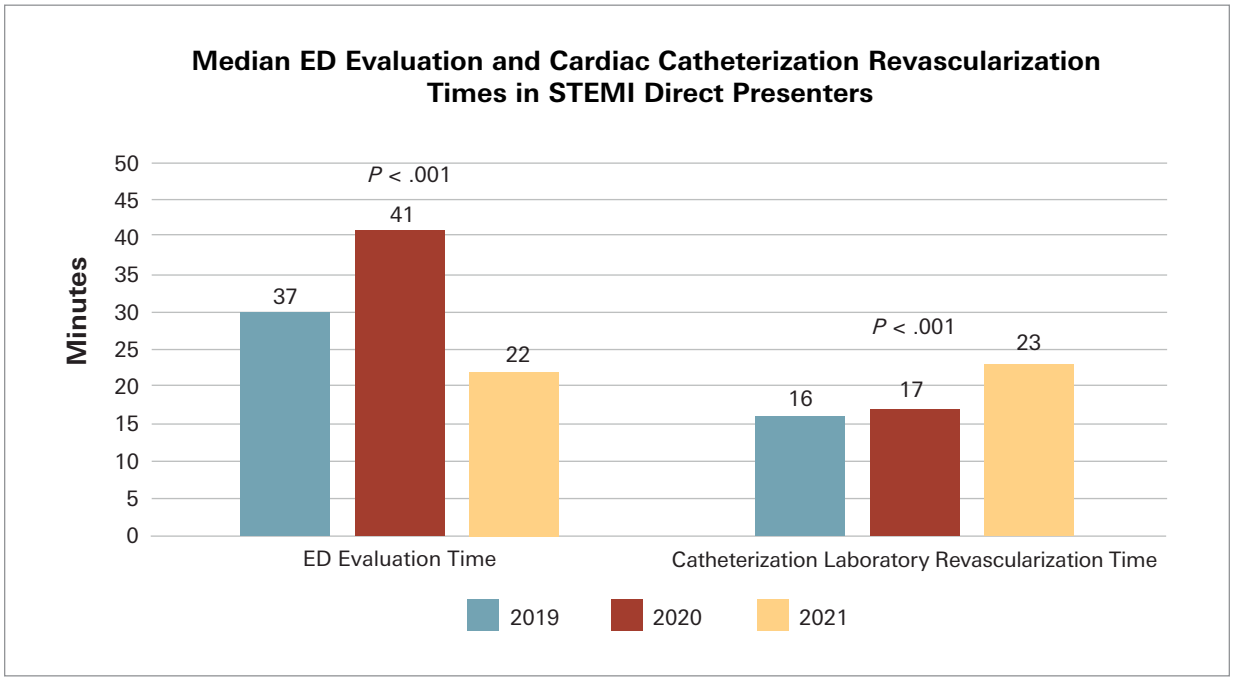

Fig. 2 Median ED evaluation times for direct presenters increased significantly in 2020 and subsequently decreased in 2021. There was no significant difference in median revascularization times after transfer to the cardiac catheterization laboratory in 2019 and 2020, with a significant increase in 2021. P ≤ .05 is considered significant.

ED, emergency department; STEMI, ST-segment elevation myocardial infarction.

TABLE III. In-Hospital Mortality Risk Factors and Outcomes

Characteristic	No. (%) of patients			*P* value[a]
	2019 (n = 251)	2020 (n = 271)	2021 (n = 267)	
In-hospital mortality	9 (3.6)	14 (5.2)	17 (6.4)	.352
COVID-19 death	0 (0.0)	1 (0.4)	0 (0.0)	.384
Clinical presentation				
Late presentation >12 h	15 (6.0)	21 (7.7)	33 (12.4)	.028[b]
Preprocedure cardiogenic shock	17 (6.8)	23 (8.5)	17 (6.4)	.602
Preprocedure cardiac arrest	22 (8.8)	29 (10.7)	27 (10.1)	.751
Status post–intravenous thrombolysis	4 (1.6)	4 (1.5)	8 (3.0)	.384
Mechanical complications	0 (0)	4 (1.5)	0 (0)	.021[c]

[a] $P \leq .05$ is considered significant.
[b] $P = .036$ for 2019 vs 2021.
[c] Post hoc comparisons with correction are not significant.

ic. A study by Rinfret et al[12] that used a countrywide survey in Canada from all cardiac catheterization laboratories found a 16% reduction of STEMI PCI during the first wave of the pandemic compared with the control period. These reports have been updated by other studies showing an actual increase in STEMI volume following the initial wave of the pandemic. Indeed, a study by Trabattoni et al[16] from Italy demonstrated that the total acute coronary syndrome volume increased in 2020 by 55% and STEMI volume by 46%.[16] These findings are in contrast to initial data from the Italian experience showing a decrease in acute coronary syndrome presentations during the country's initial lockdown period.[10]

Impact on STEMI Treatment Times

Multiple studies have reported on the impact of the pandemic on quality metrics, including DTB and FMC-D times.[17-21] In a study by Fardman et al[17] from Israel, the median time from hospital admission to reperfusion in patients with STEMI increased significantly by 7 minutes in the COVID-19 era. In another study by Kite et al[18] that compared data from the International COVID-ACS Registry with 2018-2019 data from the British Cardiovascular Intervention Society, mean DTB time increased significantly by 46 minutes in the COVID-STEMI population. Last, in a study by Garcia et al,[19] data from 18 STEMI centers in the United States were collected before and after the initiation of pandemic mitigation measures. The study demonstrated that DTB time increased on average by 20%. The present study results are in agreement with these previous reports, with initial increases in both DTB and FMC-D times in direct presenters and an increase in FMC-D time in transfer patients in 2020, followed by improvement in all treatment times in 2021.

An important factor underlying prolonged treatment times has been the necessary assessment of admitted patients by ED personnel to diagnose and treat possible COVID-19 illness, including nasopharyngeal testing for the virus and possible additional testing, including chest x-ray, echocardiogram, and chest computed tomography examination. By definition, this obligatory pre-PCI ED evaluation has eliminated the time saved through catheterization laboratory preactivation. Before the onset of the COVID-19 pandemic, routine STEMI care included obtaining a prehospitalization electrocardiogram by emergency medical services personnel, notification of an incoming STEMI case, and potential bypass of the ED. As documented in the present study, increases in DTB and FMC-D times in direct presenters in 2020 were related to an increase in the time of ED evaluation, with no significant change in the time of coronary revascularization following entry into the cardiac catheterization laboratory. Moreover, with ongoing standardization of viral testing and patient triage, decreases in ED evaluation time in 2021 were associated with improvements in all treatment times.

Another important factor that may have affected an institution's ability to respond to patients with STEMI in an appropriate format in 2020 and 2021 is the impact of COVID-19 illness or quarantine on hospital personnel, resulting in critical staff shortages; however, this factor was not relevant to the current study because ED and

cardiac catheterization staffing at the hospital remained unchanged from 2019 to 2021.

Impact on Mortality

Although the increase in observed mortality in 2020 and 2021 compared with 2019 was not statistically significant, several important observations should be made. First, death secondary to COVID-19 illness was documented in only 1 patient in 2020, accounting for a small percentage of the 40 patients who died during the 3 time periods. Second, apart from the fact that longer DTB and FMC-D times have been associated with increasing STEMI mortality, late patient presentation after the onset of symptoms, preprocedure cardiac arrest, and presentation with cardiogenic shock have all been identified as independent predictors of in-hospital death. Finally, late mechanical complications were noted in the 2020 subgroup, with a $P = .021$ compared with 2019 and 2021.

The results of the current study support these observations and are in agreement with previous reports describing the impact of the COVID-19 pandemic on STEMI mortality.[3,11,14,17,22-25] A study by Wilson et al[11] from the United Kingdom showed a trend toward higher in-hospital mortality, although this trend was not statistically significant (14.5% vs 11.0%; $P = .47$) in a comparison of before and during the COVID-19 pandemic. In a German registry report,[15] there was a higher prevalence of cardiogenic shock and preprocedure cardiac arrest (21.9% vs 14.2 and 14.3% vs 11.1% respectively; $P < .01$) in a comparison of 2020 data and 2006-2019 data. Moreover, mortality increased from 8.4% to 12.8% ($P < .01$).[15] Similarly, Fardman et al found not only a significant increase in both cardiogenic shock and in-hospital mortality during the pandemic but also a 4-fold increase in mechanical complications (free-wall rupture, ventricular septal defect, or moderate or severe mitral regurgitation).

Potential Factors Underlying STEMI Outcomes in 2021

Several possible explanations may account for the observed improvements in STEMI treatment times without significant improvement in mortality during 2021. As discussed above, obligatory treatment pathways were established early in the pandemic for the ED clinical assessment, nasopharyngeal polymerase chain reaction testing, and triage with possible isolation for all patients presenting to the hospital. Although an immediate effect of this policy was to invalidate the potential time benefit of catheterization laboratory preactivation with bypass of the ED, the efficiency of this process has improved with a decreasing amount of time spent in the ED. A proposal to potentially further improve this process is to perform initial patient assessment with viral testing in the catheterization laboratory, allowing for the return of prepandemic catheterization laboratory preactivation with complete bypass of the ED and transport of the patient directly to the catheterization suite.

Despite improving treatment times in 2021, observed in-hospital mortality has not significantly decreased. One possible explanation for this finding is the persistence of increased late presentation in 2021 patients. An increase in late presentation and preprocedure complications as a result of patient reluctance to seek emergency medical care has been documented during the pandemic.[26-28] Despite decreasing numbers of COVID-19 infections, the availability of improved COVID-19 treatment modalities, increasing patient vaccinations, and efforts to increase public awareness of the consequences of delaying urgent care, the results of this study suggest that patient delays in seeking urgent evaluation and treatment are still widespread.

Study Limitations

This study has multiple important limitations. First, this is a single-center, retrospective study, and the data might not be generalizable especially with the previously mixed results from other published reports. Second, the small volume of studied patients and their adverse outcomes did not provide sufficient power to detect statistically significant differences with respect to preprocedure events, including cardiac arrest and cardiogenic shock, and subsequent mortality. Future studies with increased patient volume allowing for appropriate statistical power are required to confirm these results. Third, patient mortality was not risk stratified. Finally, a full understanding of the impact of COVID-19 on patients with acute coronary syndromes must include data on patients with unstable angina and non-STEMI, as well as the STEMI population.

Conclusion

Apart from the negative impact of COVID-19 on STEMI outcomes directly related to mortality secondary to patient infection, the pandemic has resulted in a deleterious interruption of routine STEMI care, resulting in delays in patient evaluation and triage and subsequent prolongation of revascularization times. Equally important, patients' reluctance to seek immediate medical care has resulted in the increased treatment of patients longer after symptom onset and the decreased efficacy of urgent coronary recanalization, with higher levels of preprocedure cardiac arrest, cardiogenic shock, and late mechanical complications. The combination of systemic COVID-19 illness, prolongation of percutaneous revascularization times, and delayed patient presentation have all contributed to an increase in observed in-hospital STEMI mortality. Ongoing efforts to reestablish the timely benefits of catheterization laboratory preactivation, coupled with support of media campaigns to avoid patient delays in seeking emergency medical treatment, will be necessary to restore the quality of STEMI care to prepandemic levels.

Published: 13 March 2023

Conflict of Interest Disclosures: None

Funding/Support: None

References

1. Xiang D, Xiang X, Zhang W, et al. Management and outcomes of patients with STEMI during the COVID-19 pandemic in China. *J Am Coll Cardiol.* 2020;76(11):1318-1324. doi:10.1016/j.jacc.2020.06.039
2. Fileti L, Vecchio S, Moretti C, et al. Impact of the COVID-19 pandemic on coronary invasive procedures at two Italian high-volume referral centers. *J Cardiovasc Med (Hagerstown).* 2020;21(11):869-873. doi:10.2459/JCM.0000000000001101
3. Rodríguez-Leor O, Cid-Álvarez B, et al. Impact of COVID-19 on ST-segment elevation myocardial infarction care. The Spanish experience. *Rev Esp Cardiol (Engl Ed).* 2020;73(12):994-1002. doi:10.1016/j.rec.2020.08.002
4. Rebollal-Leal F, Aldama-López G, Flores-Ríos X, et al. Impact of COVID-19 outbreak and public lockdown on ST-segment elevation myocardial infarction care in Spain. *Cardiol J.* 2020;27(4):425-426. doi:10.5603/CJ.a2020.0098
5. Chan DZ, Stewart RA, Kerr AJ, et al. The impact of a national COVID-19 lockdown on acute coronary syndrome hospitalisations in New Zealand (ANZACS-QI 55). *Lancet Reg Health West Pac.* 2020;5:100056. doi:10.1016/j.lanwpc.2020.100056
6. Arai R, Fukamachi D, Ebuchi Y, et al. Impact of the COVID-19 outbreak on hospitalizations and outcomes in patients with acute myocardial infarction in a Japanese single center. *Heart Vessels.* 2021;36(10):1474-1483. doi:10.1007/s00380-021-01835-w
7. Boeddinghaus J, Nestelberger T, Kaiser C, et al. Effect of COVID-19 on acute treatment of ST-segment elevation and non-ST-segment elevation acute coronary syndrome in northwestern Switzerland. *Int J Cardiol Heart Vasc.* 2020;32:100686. doi:10.1016/j.ijcha.2020.100686
8. The Office of Governor Ned Lamond. Governor Lamont announces first positive case of novel coronavirus involving a Connecticut resident. News release. March 8, 2020. Accessed December 19, 2022. https://portal.ct.gov/Office-of-the-Governor/News/Press-Releases/2020/03-2020/Governor-Lamont-Announces-First-Positive-Case-of-Novel-Coronavirus-Involving-a-Connecticut-Resident
9. Zaleski AL, Taylor BA, McKay RG, Thompson PD. Declines in acute cardiovascular emergencies during the COVID-19 pandemic. *Am J Cardiol.* 2020;129:124-125. doi:10.1016/j.amjcard.2020.05.029
10. De Filippo O, D'Ascenzo F, Angelini F, et al. Reduced rate of hospital admissions for ACS during COVID-19 outbreak in Northern Italy. *N Engl J Med.* 2020;383(1):88-89. doi:10.1056/NEJMc2009166
11. Wilson SJ, Connolly MJ, Elghamry Z, et al. Effect of the COVID-19 pandemic on ST-segment-elevation myocardial infarction presentations and in-hospital outcomes. *Circ Cardiovasc Interv.* 2020;13(7):e009438. doi:10.1161/CIRCINTERVENTIONS.120.009438
12. Rinfret S, Jahan I, McKenzie K, et al. The COVID-19 pandemic and coronary angiography for ST-elevation myocardial infarction, use of mechanical support, and mechanical complications in Canada: a Canadian Association of Interventional Cardiology national survey. *CJC Open.* 2021;3(9):1125-1131. doi:10.1016/j.cjco.2021.04.017
13. Tumminello G, Barbieri L, Toriello F, et al. S. Influence of different COVID-19 pandemic phases on STEMI: experience from an Italian hub centre. *Cardiovasc Revasc Med.* 2022;37:149-152. doi:10.1016/j.carrev.2021.07.009
14. Tomasoni D, Adamo M, Italia L, et al. Impact of COVID-2019 outbreak on prevalence, clinical presentation and outcomes of ST-elevation myocardial infarction. *J Cardiovasc Med (Hagerstown).* 2020;21(11):874-881. doi:10.2459/JCM.0000000000001098
15. Scholz KH, Lengenfelder B, Thilo C, et al. Impact of COVID-19 outbreak on regional STEMI care in Germany. *Clin Res Cardiol.* 2020;109(12):1511-1521 doi:10.1007/s00392-020-01703-z.
16. Trabattoni D, Ravagnani PM, Merlino L, Montorsi P, Bartorelli AL. The bimodal "rise and fall" ACS curve overlapping COVID-19 pandemic peaks. *Am J Cardiovasc Dis.* 2021;11(3):295-299.
17. Fardman A, Zahger D, Orvin K, et al. Acute myocardial infarction in the COVID-19 era: incidence, clinical characteristics and in-hospital outcomes—a multicenter registry. *PLoS One.* 2021;16(6):e0253524. doi:10.1371/journal.pone.0253524
18. Kite TA, Ludman PF, Gale CP, et al. International prospective registry of acute coronary syndromes in patients with COVID-19. *J Am Coll Cardiol.* 2021;77(20):2466-2476. doi:10.1016/j.jacc.2021.03.309
19. Garcia S, Stanberry L, Schmidt C, et al. Impact of COVID-19 pandemic on STEMI care: an expanded analysis from the United States. *Catheter Cardiovasc Interv.* 2021;98(2):217-222. doi:10.1002/ccd.29154
20. Kobo O, Efraim R, Saada M, et al. The impact of lockdown enforcement during the SARSCoV-2 pandemic on the timing of presentation and early outcomes of patients

with ST-elevation myocardial infarction. *PLoS One.* 2020;15(10):e0241149. doi:10.1371/journal.pone.0241149
21. Chew NW, Sia CH, Wee HL, et al. Impact of the COVID-19 pandemic on door-to-balloon time for primary percutaneous coronary intervention—results from the Singapore Western STEMI Network. *Circ J.* 2021;85(2):139-149. doi:10.1253/circj.CJ-20-0800
22. Marijon E, Karam N, Jost D, et al. Out-of-hospital cardiac arrest during the COVID-19 pandemic in Paris, France: a population-based, observational study. *Lancet Public Health.* 2020;5(8):e437-443. doi:10.1016/S2468-2667(20)30117-1
23. Rattka M, Dreyhaupt J, Winsauer C, et al. Effect of the COVID-19 pandemic on mortality of patients with STEMI: a systematic review and meta-analysis. *Heart.* 2021;107:482-487. doi:10.1136/heartjnl-2020-318360
24. Kitahara S, Fujino M, Honda S, et al. COVID-19 pandemic is associated with mechanical complications in patients with ST-elevation myocardial infarction. *Open Heart.* 2021;8(1):e001497. doi:10.1136/openhrt-2020-001497
25. Rattka M, Stuhler L, Winsauer C, et al. Outcomes of patients with ST-segment elevation myocardial infarction admitted during COVID-19 pandemic lockdown in Germany—results of a single center prospective cohort study. *Front Cardiovasc Med.* 2021;8:638954. doi:10.3389/fcvm.2021.638954
26. Derks L, Sturkenboom HN, Zaal M, et al. Association between public media and trends in new acute coronary syndrome presentations during the first COVID-19 wave in the Netherlands. *Neth Heart J.* 2021;29(11):577-583. doi:10.1007/s12471-021-01603-5
27. Erol MK, Kayıkçıoğlu M, Kılıçkap M, et al. Treatment delays and in-hospital outcomes in acute myocardial infarction during the COVID-19 pandemic: a nationwide study. *Anatol J Cardiol.* 2020;24(5):334-342. doi:10.14744/AnatolJCardiol.2020.98607
28. Coughlan JJ, Chongprasertpon N, Arockiam S, Arnous S, Kiernan TJ. COVID-19 and STEMI: a snapshot analysis of presentation patterns during a pandemic. *Int J Cardiol Heart Vasc.* 2020;30:100546. doi:10.1016/j.ijcha.2020.100546