ORIGINAL ARTICLE

CLINICAL MEMORY OF COVID-19 PANDEMIC: A COMPARATIVE ANALYSIS OF CLINICAL AND ANGIOGRAPHIC CHARACTERISTICS OF PATIENTS WITH ACUTE CORONARY SYNDROME

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Objectives: To describe the clinical characteristics and angiographic features of COVID-19 patients presenting with acute coronary syndrome (ACS) and to compare with non-COVID-19 ACS patients presenting simultaneously.

Methodology: In a case control design, data were extracted from a prospectively collected COVID-19 and NCDR registry. All ACS patients who underwent cardiac catheterization from April 2020 to May 2021 were included. All of the patients were taken to the Cath lab for diagnostic coronary angiography and possible percutaneous intervention. Demographic and clinical characteristics, angiographic features, and in-hospital outcomes were compared between ACS patients with and without COVID-19.

Results: A total of 4027 COVID-19 negative patients, and 80 COVID-19 positive were included. Total of 83% in COVID-19 and 88% in non-COVID-19 group had ST elevation myocardial infarction. Majority of the COVID-19 positive patients had sub-optimal TIMI flow grade (<III) post procedure and had a high thrombus burden (11.2% vs. 2.9%; p<0.001). Majority of the patients who had COVID-19 and ACS required mechanical circulatory support (48.8% vs. 0.3%; p<0.001). The mortality rates were also higher in COVID-19 positive group (38.8% vs. 1.3%; p<0.001). Among the COVID-19 positive patients 66.3% (53) had high thrombus burden (≥4 grade), intervention was performed in 73.7% (59). Post-intervention myocardial blush grade ≤2 was observed in 57.6% (34), slow flow in 85.3% (29), and phasic flow possibly due to elevated LVEDP in 41.2% (14) patients.

Conclusion: COVID-19 patients with ACS had a higher severity of illness at presentation and worse outcomes as compared to simultaneously presenting non-COVID patients.

Keywords: COVID-19, ACS, TIMI, PCI, STEMI, NSTEMI, NCDR

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INTRODUCTION

COVID-19 was declared a pandemic by the World Health Organization on March 11, 2020.[1] The disease has spread all over the world and has imposed social containment so called lock-down in many parts. It is caused by the SARS-CoV2 virus and is highly contagious disease which may result in severe respiratory failure and premature death.[1]

The healthcare system of every country is currently focusing on COVID-19 but we all must not forget the detrimental effects of ACS on effected individuals for which treatment can be deployed immediately.[2] The clinical spectrum of ACS may range from ST-elevation MI (STEMI), which generally reflects an acute total coronary occlusion of coronary artery, to non-ST-segment elevation (NSTEMI) or unstable angina (UA), with or without myocardial injury respectively.[2] It has been observed that patients with more cardiovascular risk factors are more likely to get effected from COVID-19 and concomitant heart disease like acute myocardial infarction (AMI).[3]

It has been observed that patients with heart disease do not seek medical care for acute events because of fear to acquire COVID-19 infection and this in turn leads to adverse outcomes.[4] This fear might prolong the time from the “onset of symptoms” to “first medical contact (FMC)” leading to detrimental effects.[5]

A reduction in the number of hospitalizations with AMI, including STEMI and NSTEMI has been observed in various studies.[6] The serious implications are suggestive of deaths of many patients in the community without seeking emergency medical care. Furthermore, system related factors might add to the delay in providing emergency medical care to patients with AMI in emergency department (ED) requiring additional time for COVID-19 testing and other diagnostic tests such as "chest X-ray" and "computed tomography (CT)" and probably longer duration for transfer of COVID-19 patients to the "cardiac catheterization lab".[7] In an attempt to protect health care providers from acquiring COVID-19 infection, some countries have re-constructed their treatment strategy for STEMI and fibrinolysis is the first line of treatment. But in our part of the world, this is not the case and primary PCI for STEMI remains the first choice. Guideline directed medical therapy (GDMT) for low-risk NSTEMI and early invasive strategy has been deployed for high risk NSTEMI patients.[8-11]

Patients with cardiovascular risk factors or established cardiovascular disease are more likely to experience severe COVID-19 illness requiring ICU care, mechanical ventilation, vasopressors for hemodynamic support, and mechanical circulatory support including extracorporeal membrane oxygenation (ECMO).[3,7,12,13]

STEMI in COVID-19 patients are expected to have higher thrombus burden due to increased inflammation, platelet activation, endothelial dysfunction which may lead to complications during PCI, like slow flow or no-reflow, warranting thrombus aspiration and intra coronary medications for treatment. Acute stent thrombosis and re-infarction is a major setback of high thrombus burden.[6, 7]

Various conditions such as coronary artery vasospasm, myo-pericarditis, stress-induced cardiomyopathy, or pulmonary embolism may clinically mimic the STEMI in COVID-19 patients. Angiography may reveal a variety of findings including obstructive coronary artery disease (CAD), non-obstructive CAD and normal epicardial coronary arteries.[14]

A multiple studies around the globe have reported elevated serum troponin levels, both initially and then rising levels subsequently, to be associated with worsened "left ventricular systolic function" and a higher "intracoronary thrombus burden" and mortality.[15]

To the best of our knowledge, local studies lack significant information on the clinical presentations, demographics, risk factors and angiographic profiles of patients with ACS and COVID-19 infection. The management strategies to overcome the detrimental effects on morbidity and mortality of effected individuals and their clinical outcomes needs keen evaluation for the local population.

In this study, we aim to evaluate impact of the "COVID-19 pandemic" on patients with ACS including STEMI. The demographics and clinical characteristics, angiographic and procedural profiles and in-hospital clinical outcomes and to compare the results between two groups, one with concomitant COVID-19 infection and the other who are non-infected.

METHODOLOGY

After approval from the ethical review board of the institution this study was conducted at a tertiary care cardiac center of Karachi, Pakistan. In a case control design, data were extracted from a prospectively collected hospital based COVID-19 registry and NCDR registry. Cases were consecutive COVID-19 positive patients with ACS who undergone cardiac catheterization registered in prospectively collected hospital based registry. Controls were the non-COVID-19 patients with ACS who underwent cardiac catheterization during the same period of April 2020 to May 2021 and registered in an ongoing prospectively collected NCDR registry. All of the patients were taken to the Cath lab for diagnostic coronary angiography and possible percutaneous coronary intervention (PCI). Demographic and clinical characteristics, angiographic features, and in-hospital outcomes were compared between patients with and without COVID-19.

Extracted data were analyzed using IBM SPSS version 21. Frequency (%) were calculated for categorical variables, mean ± standard deviation (SD) or median [interquartile rage (IQR)] were calculated for the continuous variables. Two groups were compared using Chi-square test/Fisher Exact test or t-test/Mann-Whitney U test, appropriately for categorical or continuous variables, respectively. Data were further stratified by STEMI and NSTEMI patients.

Cases were also compared with a propensity matched controls in 1:2 ratio. Demographic and clinical factors were considered for propensity matching of the two groups which included, gender, age, co-morbid conditions (such as, diabetes mellitus, hypertension, smoking, and prior cardiac disease), diagnosis (STEMI/NSTEMI), left ventricular ejection fraction (%), initial TIMI flow grade 0, and final TIMI flow grade III.

RESULTS

The total of 4107 patients reached to the catheterization laboratory with the diagnosis of either STEMI or NSTEMI, out of which 80 (1.9%) patients had positive PCR for COVID-19. Patients with COVID-19 had higher distribution of female gender (33.8% vs. 19.6%; p=0.002) and higher mean age (58.13 ± 10.91 vs. 55.34 ± 10.52; p=0.019) as compared to non-COVID-19 group respectively. Diabetes mellitus (53.8% vs. 28.4%; p<0.001) and history of prior cardiac diseases (17.5% vs. 6.7%; p<0.001) were more prevalent in COVID-19 group as compared to non-COVID-19 group. More patients in COVID-19 group were in cardiogenic shock at presentation than non-COVID-19 group with the frequency of 22.5% vs. 0.4%; p<0.001 respectively. Significantly higher number of patients in COVID-19 group required mechanical ventilation support with rate of 48.8% vs. 0.3%; p<0.001 for patients with and without COVID-19 respectively. Admission SBP of <90 mmHg was observed in 13.8% vs. 0.7%; p<0.001 in patients with and without COVID-19 respectively. Similarly, admission HR of >120 bpm was observed to be more common (11.3% vs. 1.2%; p<0.001) in patients with COVID-19 as compared to the patients without COVID-19 (Table 1).

Significantly higher number of patients in the COVID-19 had left dominant system (16.3% vs. 8.2%; p=0.011) as compared to the non-COVID patients. Findings of normal coronary angiogram was more common among patients with COVID-19 infection (12.5% vs. 0.1%; p<0.001) along with pre-procedure TIMI flow grade III (25% vs. 14.3%; p=0.007). However, final optimal flow grade (TIMI III) was achieved in significantly lesser number of patients in COVID-19 group as compared to the patients in non-COVID-19 (88.8% vs. 97.1%; p<0.001). Use of NC balloon was less frequent (48.8% vs. 83.4%; p<0.001) and use of export (10% vs. 4.1%; p=0.009) was more frequent for COVID-19 group as compared to the non-COVID-19 group respectively (Table 2). Among the COVID-19 positive patients 66.3% (53) had high thrombus burden (≥4 grade), intervention was performed in 73.7% (59) out of which 56 (94.9%) were successful. Post-intervention myocardial blush grade ≤2 was observed in 57.6% (34), slow flow in 85.3% (29), and phasic flow possibly due to elevated LVEDP in 41.2% (14) patients. In-hospital mortality occurred in 38.8% (31) of COVID patients and 1.3% (54) in COVID-negative patients, p<0.001.

Cardiogenic shock was developed in 42.5% of COVID-19 positive patients and only 0.3% of COVID-19 negative patients. Around 24% of COVID-19 positive patients developed acute pulmonary edema. Acute kidney injury was developed by the 11% of COVID-19 positive patients and one (1.3%) patient required dialysis later on. Ventricular tachycardia was developed in 8.8% of COVID-19 positive patients. Almost 2.5% of the COVID-19 positive patients developed heart blocks. Cardiac arrest was reported in 11.3% of COVID-19 positive and only 0.9% of COVID-19 negative patients. Major bleeding events were reported in 2.5% of the COVID-19 positive patients and one (1.3%) patient required blood transfusions. In-hospital mortality rate was found to be 38.8% vs. 1.3%; p<0.001 for the patients with and without COVID-19 respectively.

Table 1: Distribution of demographic and hemodynamic characteristics stratified by the COVID-19 infection

Characteristics	COVID-19		P-value
	COVID-19	Non-COVID-19	
Total (N)	80	4027	-
Gender			
Male	66.3% (53)	80.4% (3237)	0.002*
Female	33.8% (27)	19.6% (790)	
Age (years)	58.13 ± 10.91	55.34 ± 10.52	0.019*
Chest pain duration (min)	360 [175-1440]	256 [144-400]	<0.001*
Co-morbid			
Diabetes mellitus	53.8% (43)	28.4% (1144)	<0.001*
Hypertension	68.8% (55)	59.5% (2398)	0.097
Smoking	15% (12)	9.8% (396)	0.126
Prior Cardiac disease	17.5% (14)	6.7% (268)	<0.001*
Diagnosis			
ST elevation MI	83.8% (67)	88.1% (3546)	0.241
Non-ST elevation MI	16.3% (13)	11.9% (481)	
Admission systolic blood pressure			
<90 mmHg	13.8% (11)	0.7% (29)	<0.001*
90-120 mmHg	57.5% (46)	25.6% (1031)	<0.001*
121-140 mmHg	15% (12)	27.8% (1121)	0.011*
141-160 mmHg	5% (4)	12.4% (499)	0.046*
>160 mmHg	8.8% (7)	7.4% (296)	0.635
Not available	0% (0)	26.1% (1051)	-
Admission heart rate			
<60 bpm	3.8% (3)	2.6% (106)	0.538
61-70 bpm	12.5% (10)	16.4% (659)	0.354
71-80 bpm	10% (8)	25.7% (1033)	0.001*
81-90 bpm	13.8% (11)	14.5% (582)	0.860
91-100 bpm	6.3% (5)	6.9% (277)	0.826
101-110 bpm	33.8% (27)	4.7% (188)	<0.001*
111-120 bpm	8.8% (7)	2.1% (83)	<0.001*

>120 bpm	11.3% (9)	1.2% (50)	<0.001*
Not available	0% (0)	26% (1049)	-
Cardiogenic Shock			
No	77.5% (62)	73.6% (2963)	0.430
Yes	22.5% (18)	0.4% (16)	<0.001*
Not available	0% (0)	26% (1048)	-
Patient on ventilator			
No	51.3% (41)	73.4% (2954)	<0.001*
Yes	48.8% (39)	0.3% (11)	<0.001*
Not available	0% (0)	26.4% (1062)	-

COVID-19 = coronavirus disease 2019, MI = myocardial infarction
**significant at 5%*

Table 2: Cardiac catheterization findings and procedural characteristics stratified by the COVID-19 infection

Characteristics	COVID-19		P-value
	COVID-19	Non-COVID-19	
Total (N)	80	4027	-
Left ventricular ejection fraction (%)	42.5 ± 11.44	42.2 ± 9.06	0.769
Number of vessels involved			
Normal	12.5% (10)	0.1% (5)	<0.001*
Single vessel disease	28.8% (23)	47.8% (1925)	<0.001*
Two vessel disease	32.5% (26)	31.6% (1271)	0.858
Three vessel disease	26.3% (21)	20.5% (826)	0.209
Involved vessel			
None	12.5% (10)	0.1% (5)	<0.001*
Left main	1.3% (1)	1.3% (54)	0.944
Left anterior descending artery	45% (36)	54.1% (2180)	0.105
Right coronary artery	26.3% (21)	29.7% (1196)	0.503
Left circumflex	15% (12)	14.3% (574)	0.850
Ramus	0% (0)	0.4% (18)	0.549
Dominance			
Left	16.3% (13)	8.2% (332)	0.011*
Right	81.3% (65)	88% (3544)	0.067
Co-dominance	2.5% (2)	3.7% (151)	0.559
Initial Thrombolysis in Myocardial Infarction (TIMI) flow grade			
0	58.8% (47)	53.9% (2172)	0.392
I	8.8% (7)	9.4% (377)	0.852
II	7.5% (6)	22.4% (902)	0.001*
III	25% (20)	14.3% (576)	0.007*
Final Thrombolysis in Myocardial Infarction (TIMI) flow grade			
0	6.3% (5)	1.4% (56)	<0.001*
I	2.5% (2)	0.2% (9)	<0.001*
II	2.5% (2)	1.3% (53)	0.362
III	88.8% (71)	97.1% (3909)	<0.001*
Export done	10% (8)	4.1% (165)	0.009*
SC balloon used	30% (24)	35.4% (1424)	0.320
Noncompliant balloon used	48.8% (39)	83.4% (3359)	<0.001*
Stent diameter (mm)	3.24 ± 0.32	3.25 ± 0.36	0.712
Stent length (mm)	24.98 ± 10.84	27.99 ± 12.73	0.036*

COVID-19 = coronavirus disease 2019, MI = myocardial infarction
**significant at 5%*

Comparison of demographics, clinical characteristics, and cardiac catheterization findings between COVID-19 and non-COVID-19 stratified by type of acute coronary syndrome are presented in Table 3.

Comparison of propensity matched cohort of COVID-19 non-COVID-19 patients showed similar significant differences in chest pain duration, frequency of admission SBP<90 mmHg, admission HR >120 bpm, cardiogenic shock at admission, need of ventilator, normal coronaries on angiogram, length of lesion, in-hospital cardiac arrest, cardiogenic shock, and mortality (Table 4).

Table 3: Comparison of demographics, clinical characteristics, and cardiac catheterization findings between COVID-19 and non-COVID-19 stratified by type of acute coronary syndrome

Characteristics	STEMI		P-value	NSTEMI		P-value
	COVID-19	Non-COVID-19		COVID-19	Non-COVID-19	
Total (N)	67	3546	-	13	481	-
Gender						
Male	65.7% (44)	80.5% (2856)	0.002	69.2% (9)	79.2% (381)	0.384
Female	34.3% (23)	19.5% (690)		30.8% (4)	20.8% (100)	
Age (years)	58.51 ± 11.48	55.35 ± 10.64	0.016	56.15 ± 7.34	55.27 ± 9.59	0.743
Chest pain duration (min)	360 [180-1440]	256 [145-399]	<0.001	227.5 [157.5-404]	259.5 [136-410]	0.898
Co-morbid						
Diabetes mellitus	50.7% (34)	27.6% (977)	<0.001	69.2% (9)	34.7% (167)	0.010
Hypertension	71.6% (48)	58.5% (2076)	0.031	53.8% (7)	66.9% (322)	0.323
Smoking	17.9% (12)	10.1% (358)	0.037	0% (0)	7.9% (38)	0.292
Prior cardiac disease	13.4% (9)	5.7% (201)	0.007	38.5% (5)	13.9% (67)	0.029
Admission systolic blood pressure						
<90 mmHg	13.4% (9)	0.8% (29)	<0.001	15.4% (2)	0% (0)	<0.001
90-120 mmHg	56.7% (38)	28.5% (1009)		61.5% (8)	4.6% (22)	
121-140 mmHg	16.4% (11)	31% (1100)		7.7% (1)	4.4% (21)	
141-160 mmHg	4.5% (3)	13.8% (491)		7.7% (1)	1.7% (8)	

>160 mmHg	9% (6)	8.3% (295)		7.7% (1)	0.2% (1)	
Not available	0% (0)	17.5% (622)		0% (0)	89.2% (429)	
Admission heart rate						
<60 bpm	4.5% (3)	2.9% (103)		0% (0)	0.6% (3)	
61-70 bpm	10.4% (7)	18.3% (649)		23.1% (3)	2.1% (10)	
71-80 bpm	9% (6)	28.4% (1006)		15.4% (2)	5.6% (27)	
81-90 bpm	9% (6)	16.2% (574)		38.5% (5)	1.7% (8)	
91-100 bpm	6% (4)	7.8% (275)	<0.001	7.7% (1)	0.4% (2)	<0.001
101-110 bpm	38.8% (26)	5.3% (187)		7.7% (1)	0.2% (1)	
111-120 bpm	10.4% (7)	2.3% (82)		0% (0)	0.2% (1)	
>120 bpm	11.9% (8)	1.4% (50)		7.7% (1)	0% (0)	
Not available	0% (0)	17.5% (620)		0% (0)	89.2% (429)	
Cardiogenic Shock						
No	76.1% (51)	82.1% (2911)		84.6% (11)	10.8% (52)	
Yes	23.9% (16)	0.5% (16)	<0.001	15.4% (2)	0% (0)	<0.001
Not available	0% (0)	17.5% (619)		0% (0)	89.2% (429)	
Patient on ventilator						
No	46.3% (31)	81.9% (2903)		76.9% (10)	10.6% (51)	
Yes	53.7% (36)	0.3% (11)	<0.001	23.1% (3)	0% (0)	<0.001
Not available	0% (0)	17.8% (632)		0% (0)	89.4% (430)	
Left ventricular ejection fraction (%)	41.41 ± 11.53	41.84 ± 9	0.819	48.57 ± 9.45	45.77 ± 8.87	0.409
Number of vessels involved						
Normal	7.5% (5)	0.1% (3)		38.5% (5)	0.4% (2)	
Single vessel disease	32.8% (22)	47.6% (1688)	<0.001	7.7% (1)	49.3% (237)	<0.001
Two vessel disease	34.3% (23)	31.1% (1104)		23.1% (3)	34.7% (167)	
Three vessel disease	25.4% (17)	21.2% (751)		30.8% (4)	15.6% (75)	
Involved vessel						
None	7.5% (5)	0.1% (3)		38.5% (5)	0.4% (2)	
Left main	0% (0)	1.2% (44)		7.7% (1)	2.1% (10)	
Left anterior descending artery	50.7% (34)	53.8% (1908)	<0.001	15.4% (2)	56.5% (272)	<0.001
Right coronary artery	28.4% (19)	30.9% (1097)		15.4% (2)	20.6% (99)	
Left circumflex	13.4% (9)	13.4% (476)		23.1% (3)	20.4% (98)	
Ramus	0% (0)	0.5% (18)		0% (0)	0% (0)	
Dominance						
Left	16.4% (11)	7.7% (273)		15.4% (2)	12.3% (59)	
Right	82.1% (55)	88.8% (3148)	0.045	76.9% (10)	82.3% (396)	0.884
Co-dominance	1.5% (1)	3.5% (125)		7.7% (1)	5.4% (26)	
Initial Thrombolysis in Myocardial Infarction (TIMI) flow grade						
0	64.2% (43)	57% (2022)		30.8% (4)	31.2% (150)	
I	9% (6)	9.3% (329)	0.016	7.7% (1)	10% (48)	0.381
II	7.5% (5)	22.1% (782)		7.7% (1)	24.9% (120)	
III	19.4% (13)	11.6% (413)		53.8% (7)	33.9% (163)	
Final Thrombolysis in Myocardial Infarction (TIMI) flow grade						
0	7.5% (5)	1.2% (44)		0% (0)	2.5% (12)	
I	1.5% (1)	0.3% (9)	0.006	7.7% (1)	0% (0)	0.043
II	3% (2)	1.4% (49)		0% (0)	0.8% (4)	
III	88.1% (59)	97.1% (3444)		92.3% (12)	96.7% (465)	
Export done	11.9% (8)	4.5% (161)	0.012	0% (0)	0.8% (4)	>0.999
SC balloon used	31.3% (21)	34.1% (1210)	0.634	23.1% (3)	44.5% (214)	0.125
NC balloon used	55.2% (37)	82.9% (2940)	<0.001	15.4% (2)	87.1% (419)	<0.001
Stent diameter (mm)	3.23 ± 0.32	3.26 ± 0.36	0.659	3.33 ± 0.29	3.23 ± 0.35	0.623
Stent length (mm)	25.38 ± 11.06	27.78 ± 12.57	0.219	19.33 ± 5.13	29.55 ± 13.76	0.200

*MI=myocardial infarction, HF=heart failure, RV=right ventricular, LV=left ventricular, TIMI=thrombolysis in myocardial infarction, CVA=cerebrovascular accident, MACE=major adverse cardiovascular event, *=significant*

Table 4: Distribution of demographic, hemodynamic, angiographic, and clinical characteristics for 1:2 propensity matched cohort of COVID-19 and non-COVID-19 patients

Characteristics	**COVID-19**		**P-value**
	COVID-19	**Non-COVID-19**	
Total (N)	80	160	-
^Gender			
Male	66.3% (53)	64.4% (103)	0.774
Female	33.8% (27)	35.6% (57)	
^Age (years)	58.13 ± 10.91	58.86 ± 10.07	0.604

Chest pain duration (min)	360 [175-1440]	252 [163-385]	0.006*
Co-morbid			
^Diabetes mellitus	53.8% (43)	52.5% (84)	0.855
^Hypertension	68.8% (55)	75% (120)	0.304
^Smoking	15% (12)	10.6% (17)	0.327
^Prior Cardiac disease	17.5% (14)	21.3% (34)	0.494
^Diagnosis			
ST elevation MI	83.8% (67)	81.9% (131)	0.719
Non-ST elevation MI	16.3% (13)	18.1% (29)	
Admission systolic blood pressure			
<90 mmHg	13.8% (11)	0% (0)	<0.001*
90-120 mmHg	57.5% (46)	25.6% (41)	<0.001*
121-140 mmHg	15% (12)	27.5% (44)	0.031*
141-160 mmHg	5% (4)	10.6% (17)	0.146
>160 mmHg	8.8% (7)	6.3% (10)	0.477
Not available	0% (0)	30% (48)	-
Admission heart rate			
<60 bpm	3.8% (3)	1.3% (2)	0.201
61-70 bpm	12.5% (10)	17.5% (28)	0.317
71-80 bpm	10% (8)	26.3% (42)	0.003*
81-90 bpm	13.8% (11)	11.9% (19)	0.679
91-100 bpm	6.3% (5)	5.6% (9)	0.846
101-110 bpm	33.8% (27)	4.4% (7)	<0.001*
111-120 bpm	8.8% (7)	3.1% (5)	0.059
>120 bpm	11.3% (9)	0% (0)	<0.001*
Not available	0% (0)	30% (48)	-
Cardiogenic Shock			
No	77.5% (62)	68.8% (110)	0.156
Yes	22.5% (18)	1.3% (2)	<0.001*
Not available	0% (0)	30% (48)	-
Patient on ventilator			
No	51.3% (41)	70% (112)	0.004*
Yes	48.8% (39)	0% (0)	<0.001*
Not available	0% (0)	30% (48)	-
^Left ventricular ejection fraction (%)	42.5 ± 11.44	42.41 ± 9.38	0.950
Number of vessels involved			
Normal	12.5% (10)	0% (0)	<0.001*
Single vessel disease	28.8% (23)	40% (64)	0.087
Two vessel disease	32.5% (26)	34.4% (55)	0.772
^Three vessel disease	26.3% (21)	25.6% (41)	0.917
Involved vessel			
None	12.5% (10)	0% (0)	<0.001*
Left main	1.3% (1)	0.6% (1)	0.616
Left anterior descending artery	45% (36)	49.4% (79)	0.522
Right coronary artery	26.3% (21)	31.9% (51)	0.370
Left circumflex	15% (12)	17.5% (28)	0.624
Ramus	0% (0)	0.6% (1)	0.479
Dominance			
Left	16.3% (13)	8.1% (13)	0.056
Right	81.3% (65)	87.5% (140)	0.196
Co-dominance	2.5% (2)	4.4% (7)	0.471
Initial Thrombolysis in Myocardial Infarction (TIMI) flow grade			
^0	58.8% (47)	48.8% (78)	0.144
I	8.8% (7)	13.1% (21)	0.320
II	7.5% (6)	24.4% (39)	0.002*
III	25% (20)	13.8% (22)	0.031*
Final Thrombolysis in Myocardial Infarction (TIMI) flow grade			
0	6.3% (5)	3.1% (5)	0.253
I	2.5% (2)	0% (0)	0.045*
II	2.5% (2)	1.9% (3)	0.749
^III	88.8% (71)	95% (152)	0.075
Export done	10% (8)	4.4% (7)	0.090
SC balloon used	30% (24)	33.1% (53)	0.625
Noncompliant balloon used	48.8% (39)	86.9% (139)	<0.001*
Stent diameter (mm)	3.24 ± 0.32	3.21 ± 0.36	0.558
Stent length (mm)	24.98 ± 10.84	29.1 ± 13.6	0.019*

In-hospital complications			
Bleeding	2.5% (2)	0.63% (1)	0.218
Cardiac Arrest	11.3% (9)	1.9% (3)	0.002*
Cardiac Tamponade	0% (0)	0% (0)	-
Cardiogenic shock	42.5% (34)	0.6% (1)	<0.001*
Heart Failure	0% (0)	0.6% (1)	0.479
Post procedural MI	0% (0)	0% (0)	-
AKI requiring Dialysis	1.3% (1)	0% (0)	-
Other Vascular Complications Requiring Treatment	0% (0)	0% (0)	-
CVA	0% (0)	0% (0)	-
Atrial Fibrillation	1.3% (1)	-	-
Ventricular Fibrillation	1.3% (1)	-	-
Ventricular Tachycardia	8.8% (7)	-	-
Transfusion	1.3% (1)	-	-
MR	1.3% (1)	-	-
VSR	2.5% (2)	-	-
Acute Pulmonary Edema	23.8% (19)	-	-
AKI	11.3% (9)	-	-
3 Heart block	2.5% (2)	-	-
In-hospital mortality	38.8% (31)	3.8% (6)	<0.001*

COVID-19 = coronavirus disease 2019, MI = myocardial infarction
**significant at 5%*
^ Propensity matching parameter

DISCUSSION

The optimal management of patients with STEMI and COVID-19 presents a greater challenge for health care system as compared to the pre-pandemic era[12,13,16] STEMI in general is associated with an increased risk of morbidities and mortality and among various other factors it can be influenced by patient characteristics and co-morbid conditions.[16] Few viral respiratory infections including influenza have been reported to act as triggers for AMI.[17] Hence, it can be hypothesized that the COVID-19 infection and systemic inflammatory response may trigger STEMI events in many cases.[17]

We studied the impact during one year of pandemic (April 2020- May 2021) and compared the data of two groups i.e., one with COVID-19 infection and the other who are not infected.

We observed that during this one year of COVID-19 pandemic, lesser number of patients with ACS attended ER than the previous year. As we sub divided the patients into COVID-19 positive and COVID-19 negative group, we further found out that the number of STEMI cases has also decreased as compared to the previous years. This trend has been observed all over the world and various studies highlighted the matter.[4,6] A logical explanation could be the fear to acquire COVID-19 infection through hospital and health care staff and subsequently transmitting the infection to the close contacts. This avoidance behavior let the patients to hold back with their medical issues and a later presentation and critical illness.[5] We also observed that those ACS patients who had concomitant COVID-19 infection, majority had STEMI. This again implies that only those who had severe symptoms rushed to the ER while those who had mild illness preferred to stay at home.[16] We did not observe the prevalence of out of the hospital cardiac arrest in the setting of ACS. Neither we did include the patients who died in ER. The proportion of male patients was higher as compared to the females. Possible explanation could be delayed care provision to females by default in our society. Few studies have highlighted that increased environmental exposure is directly related to increased rate of infection in males as compared to females. Moreover, some studies showed that females have perceived COVID-19 as a more serious disease and were more eager to take precaution, wearing face masks and practice social distancing as compared to the males.[18-20] Majority of the patients were of middle to old age which means the older people were getting serious illness during the pandemic.

We preferred primary PCI for all STEMI patients irrespective of their COVID-19 status. Although various countries have adapted different guidelines in view of the COVID-19 outbreak.[8-11] Some preferred thrombolysis for STEMI. But in our part of the world, this is not the case. Those patients who had NST-ACS and severe symptoms were also taken to the cath lab for coronary angiography and possible intervention. Patients who were comparatively stable and had mild symptoms were stabilized and then followed up in outpatient department for further decision.

In our study, majority of the patients with COVID-19 infection and ACS had a history of prior CAD as compared to the non-covid group. Overall fear, stress and depression related to the pandemic can lead to increased cardiovascular morbidity.[21] The lock down state has put an enormous financial strain to the community which may render the availability of regular medications.[22] People may drop their daily doses either because of no money or because they fear to acquire COVID-19 infection as they step out of the house to get their medicines. We have also observed that patients with COVID-19 and ACS were majority smokers. This is again explainable with the immensely stressful/depressive environment that led people to smoke more.[21]

Various studies showed a high prevalence of nonobstructive coronary artery disease in COVID-19 and ACS patients.[23] We also observed similar trend. A few patients with COVID-19 infection and ACS showed either normal or non-obstructive coronaries. In our study, we did not establish alternative diagnosis such as myocarditis, takotsubo syndrome and pulmonary embolism etc. for non-obstructive CAD.

Patients with ACS and COVID-19 may have significant thrombus burden. There are many theories regarding the mechanism of increased thrombus burden. One possibility is the pro inflammatory state that leads to increased inflammation, platelet activation, endothelial dysfunction which may lead to slow flow or no-reflow during PCI. Acute stent thrombosis and re-infarction is again a major dilemma of high thrombus.[17,24] We found a greater number of patients with final TIMI score 0 as compared to the non-COVID patients. Similarly, the use of export catheters for thrombus aspiration was high in COVID positive group and post dilatation after stent deployment was deferred in more patients with COVID-19 positive status in order to avoid thrombus disruption and embolization.

We did not find any difference in the culprit artery involvement in both groups. Triple vessel disease was more common in patients with ACS and concomitant COVID-19 infection. A plausible explanation is their established history of CAD.

A particularly relevant finding of our study is a disturbing elevation in in-hospital morbidity and mortality during the pandemic. Patients who had concomitant COVID-19 infection and had STEMI were sicker. Majority of them required ventilatory support either before or after the cardiac cath procedure. The use of pharmacological support for stabilizing hemodynamics was also higher in the covid infected group. IABP was used frequently in covid infected group.

We observed that the proportion of patients who developed cardiogenic shock requiring MCS was higher in the COVID-19 infected patients, a plausible explanation is increased risk of STEMI-related complication conferred by COVID-19 itself and the late seeking behavior of patients that has led their disease to aggravate up to critical extent.[23,25] Older age, more co-morbids and prior CAD history all add up to the grave situation.

We observed an increased trend in ventricular tachycardia, atrial fibrillation, heart blocks and in-hospital cardiac arrest in patients with ACS and COVID-19 infection. Major bleeding events requiring blood transfusion were also higher in COVID-19 group. STEMI related complications like MR and VSR were also higher in COVID-19 infected group. We found no difference in the prevalence of heart failure in both groups.

A great number of patients who had concomitant COVID-19 infection and ACS died during hospital stay because of critical illness and high-risk STEMI-related complications. Almost half of the patients with ACS and COVID-19 infection were discharged home safely but in the long term how this disease has affected them is yet a question.

This is a retrospective study. Patients who died at presentation in the ER were not enrolled in the study. Those patients who were late for intervention were also not included. Only in-hospital outcomes were observed. The long-term implications of COVID-19 infection to the patients who survived are still not known to us.

CONCLUSION

During the COVID-19 pandemic, a reduction in STEMI patients' admission in our hospital is noted. Also, COVID-19 outbreak led to delayed patient presentation and somehow delayed treatment. COVID-19 positive STEMI patients represent high risk patients' group as thrombus burden and mortality rate were higher in these patients. The proportion of patients with cardiogenic shock requiring MCS was significantly higher in COVID-19 positive sub group. There is need to create more awareness through social media and other platforms regarding identification of symptoms of MI and prompt arrival to the ER so that the risk of high morbidity and mortality can be minimized. To know COVID-19 status is an essential part to filter high risk population and furthermore, awareness must be created in the society to get tested and to not consider it a social taboo. Primary PCI is the optimal treatment of choice for STEMI regardless of COVID-19 status. Further studies are needed to understand the mechanism of high coronary thrombus burden and impact of COVID-19 on poor outcomes in these patients.

AUTHORS' CONTRIBUTION

ASM and AA: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. BK, DQ, UHB, MH, AA, TS, FA, and NS: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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