

Influence of COVID-19 on Clinical Outcomes among Patients Hospitalized with ST-Segment Elevation Myocardial Infarction

Fatma Hussein Abdelwahab¹, Ibtesam Ibrahim Ahmed²

¹ Faculty of Medicine, Alexandria University, Alexandria 21526, Egypt.

² International Cardiac Center, Alexandria 21526, Egypt.

Abstract

Primary percutaneous coronary intervention (PPCI), a key therapeutic procedure for ST-segment elevation myocardial infarction (STEMI), experienced major disruption during the COVID-19 crisis. This study investigated how the pandemic influenced both the frequency of PPCI procedures and the short-term hospital outcomes of STEMI patients. Using a retrospective observational approach, data were collected from consecutive patients admitted to the International Cardiac Center (ICC) in Alexandria, Egypt, between February 1 and October 31, 2020. For comparison, records from an equivalent period in 2019 were analyzed as a control group. Patients with a confirmed STEMI diagnosis requiring PPCI were included. In total, 634 cases were examined. The number of PPCI interventions fell by 25.7% during the pandemic period (average 30.0 ± 4.01 vs. 40.4 ± 5.3 cases monthly), and the delay between initial medical contact and needle time (FMC-to-N) increased significantly (125.0 ± 53.6 vs. 52.6 ± 22.8 minutes, $p = 0.001$). Furthermore, the COVID-19 group exhibited higher in-hospital mortality (7.4% vs. 4.6 percent, $p = 0.036$), greater re-infarction frequency (12.2% vs. 7.7 percent, $p = 0.041$), and increased revascularization needs (15.9% vs. 10.7 percent, $p = 0.046$). Although rates of heart failure, stroke, and bleeding did not differ significantly between groups, hospitalization duration was considerably longer during the pandemic (6.85 ± 4.22 vs. 3.5 ± 2.3 days, $p = 0.0025$). In summary, the COVID-19 outbreak led to substantial challenges in PPCI management at the ICC, including reduced case volumes, delayed interventions, and worsened in-hospital outcomes such as elevated mortality, recurrent infarction, greater revascularization demand, and prolonged recovery time.

Keywords: ST segment elevation myocardial infarction, Primary percutaneous intervention, COVID-19

Corresponding author: Ibtesam Ibrahim Ahmed

E-mail: Ibrahimiahmed@gamilc.com

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Introduction

Primary percutaneous coronary intervention (PPCI) is currently regarded as the most effective treatment for patients experiencing ST-segment elevation myocardial infarction (STEMI), in accordance with contemporary guidelines [1]. Evidence indicates that any delays in

performing PPCI can negatively affect clinical outcomes in these patients [2, 3].

Since early 2020, the COVID-19 pandemic has disrupted many aspects of healthcare, including the management of cardiovascular conditions such as acute coronary syndromes, which require urgent intervention. The World Health Organization (WHO) categorizes COVID-19 cases into four groups based on clinical presentation, laboratory findings, and exposure history: confirmed (COVID-19 +),

suspected (COVID-19 +/-), contact (COVID-19 C), and non-suspected (COVID-19 NS) [4].

The pandemic has led to notable variations in STEMI management across different regions. While some healthcare systems shifted from PPCI to fibrinolytic therapy as a primary reperfusion strategy [5–7], others continued to follow guideline-directed PPCI for all eligible patients [8–11]. Several factors contributed to these changes, including delays in patients seeking medical attention during lockdowns, additional time required for COVID-19 screening, and concerns among healthcare providers about virus transmission [12–15].

This study aimed to evaluate the impact of the COVID-19 pandemic on in-hospital outcomes among STEMI patients who underwent PPCI.

Experimental Section

Study design

This retrospective observational study included consecutive STEMI patients admitted to the International Cardiac Center (ICC) in Alexandria, Egypt, from February 1 to October 31, 2020. Eligible patients had a confirmed STEMI diagnosis, defined as ST-segment elevation ≥ 1 mm in at least two contiguous leads or new-onset left bundle branch block with typical chest pain, with or without elevated cardiac biomarkers, and were indicated for PPCI according to current guidelines [1, 16].

Exclusion criteria were prior coronary artery bypass grafting (CABG), cardiogenic shock at presentation, previous PCI of the same culprit vessel, and severe left main coronary artery disease. To provide a pre-pandemic comparison, data from STEMI patients admitted during the same period in 2019 were used as a control group. After excluding 20 patients from the 2019 cohort and 5 patients from the 2020 cohort, a total of 634 patients were analyzed:

- Group A: 364 STEMI patients treated with PPCI before the COVID-19 pandemic (2019).
- Group B: 270 STEMI patients treated with PPCI during the COVID-19 pandemic (2020).

Data collection

Patient demographics, including age, sex, and comorbidities (hypertension, diabetes, and dyslipidemia), were recorded. Procedural data included the time from symptom onset to first medical contact (FMC) and FMC-to-needle (FMC-to-N) time. Angiographic information

collected included the culprit vessel, number of diseased vessels, antithrombotic therapy administered (aspirin, clopidogrel, ticagrelor, heparin, enoxaparin, glycoprotein IIb/IIIa inhibitors), pre-dilation, stent characteristics (number, length, diameter), TIMI flow score, final procedural results, and duration of hospitalization. Post-procedural complications such as heart failure, stroke, or bleeding were also documented.

Endpoint measurements

The primary endpoints were the number of PPCI procedures performed before and during the COVID-19 period and the median FMC-to-N time. Secondary endpoints included in-hospital mortality, major adverse cardiac and cerebrovascular events (MACCE) during hospitalization, and length of hospital stay. MACCE was defined as a composite of death, re-infarction, need for revascularization, heart failure, stroke, or bleeding.

Statistical analysis

Data were analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA) [17]. Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean $\pm$ standard deviation, median, and range. The chi-square test was used for comparisons of categorical variables, with Fisher's exact test or Monte Carlo correction applied when more than 20 percent of cells had expected counts below five. Non-normally distributed continuous variables were compared using the Mann–Whitney test. A p-value < 0.05 was considered statistically significant.

Informed consent was obtained from all patients or their legal representatives, and the study was approved by the local ethics committee (approval number 0304893).

Results

Patient characteristics and procedural volume

During the COVID-19 period, PPCI procedures decreased by 25.7% compared with the same months in 2019 (30.0 ± 4.01 vs. 40.4 ± 5.3 cases per month). Both patient groups were similar in baseline demographic and clinical characteristics, with no statistically significant differences observed. Only a few patients in either group were over 65–70 years old (eight in Group A, five in Group B). Detailed baseline characteristics of the study population are summarized in **Table 1**.

Table 1. Baseline characteristics, laboratory findings, procedural characteristics of the studied populations

	Group A n = 364	Group B n = 270	p-Value
Age			
Range	36–88	35–82	
Mean $\pm$ S.D.	58.9 $\pm$ 13.35	57.1 $\pm$ 12.60	0.568

Gender					
Male	312	85.7%	220	81.5%	0.607
Female	52	14.3%	50	18.5%	
Risk factors					
Diabetes mellitus	130	35.7%	95	35.2%	0.521
Hypertension	156	42.9%	107	39.6%	0.411
Dyslipidemia	182	50.0%	122	45.2%	0.501
Smoking	208	57.1%	123	45.6%	0.364
Troponin					
Range	0.003–8.68		0.01–10.0		0.078
Mean ± S.D.	1.07 ± 2.21		1.65 ± 2.62		
CKmb					
Range	1.27–261.9		1.32–270.0		0.105
Mean ± S.D.	115.94 ± 76.29		124.3 ± 58.9		
Haemoglobin					
Range	9.3–17.1		9.5–16.0		0.524
Mean ± S.D.	13.87 ± 1.85		13.9 ± 1.71		
Lymphocytes					
Range	12–36		8–25		0.012 *
Mean ± S.D.	18.6 ± 6.21		14.78 ± 5.85		
D dimer					
Range	130–500		152–1500		0.0031 *
Mean ± S.D.	302.0 ± 132.17		505.6 ± 201.3		
Serum ferritin					
Range	72.0–135.0		85.0–166.0		0.011 *
Mean ± S.D.	93.48 ± 39.8		118.5 ± 42.51		
Serum creatinine					
Range	0.59–4.03		0.60–3.52		0.211
Mean ± S.D.	1.12 ± 0.66		1.26 ± 0.71		
FMC-to-N (min)					
Range	15–85		60.0–280		0.001 *
Mean ± S.D.	52.6 ± 22.8		125.0 ± 53.6		
	No.	%	No.	%	
MVD	43	11.8	63	23.3	0.389
SVD	321	88.2	207	76.7	
Culprit vessel					
LAD	216	59.3	128	47.4	0.089
RCA	108	29.7	97	35.9	
LCX	40	11	45	16.7	
Clopidogrel	221	60.7	155	57.3	0.410
Ticagrelor	143	39.3	115	42.7	

p value for comparing between the two studied groups. *: Statistically significant at $p \leq 0.05$.

Laboratory findings

Group B patients exhibited a significantly higher rate of lymphopenia compared with Group A (14.78 ± 5.85 vs. 18.6 ± 6.21 , $p = 0.012$). Similarly, serum ferritin and D-dimer concentrations were elevated in the COVID-19 period group. No notable differences were observed between the groups for cardiac enzyme levels, hemoglobin, or serum creatinine. A full overview of laboratory parameters is provided in **Table 1**.

Time from first medical contact to needle (FMC-to-N)

Patients treated during the COVID-19 period experienced a substantial prolongation in FMC-to-needle time relative to the pre-pandemic group (125.0 ± 53.6 vs. 52.6 ± 22.8

minutes, $p = 0.001$). The comparative FMC-to-N times for both cohorts are displayed in **Table 1**.

Procedural characteristics

Analysis of coronary angiography findings showed no significant differences in the presence of multivessel disease or the distribution of culprit vessels between the two groups. Administration of antiplatelet agents such as clopidogrel or ticagrelor was similar across cohorts. None of the patients in either group received fibrinolytic therapy. All interventions involved drug-eluting stents (DES), and no procedural complications such as dissection or perforation were reported. Post-procedural TIMI flow scores were comparable between the groups. In-hospital medical management and follow-up adhered to current STEMI guidelines [1, 16]. Procedural characteristics are summarized in **Table 1**.

In-Hospital outcomes

Mortality during hospitalization was higher among patients in Group B compared with Group A (7.4% vs. 4.6 percent, $p = 0.036$). Likewise, the frequency of recurrent myocardial infarction was elevated in the COVID-19 period group (12.2% vs. 7.7%, $p = 0.041$). Of the 20 deaths observed in Group B, the majority were due to ventricular arrhythmias such as ventricular fibrillation, while the remaining cases resulted from refractory cardiogenic shock or pulmonary edema. The need for repeat revascularization was also greater in Group B (15.9% vs. 10.7 percent, $p = 0.046$). The occurrence of heart failure and bleeding events did not differ significantly between the groups. Although stroke was more prevalent in Group A, the underlying reason remains uncertain; a potential explanation could be the higher utilization of thrombus aspiration devices during PPCI in 2019 relative to 2020. A detailed summary of procedural outcomes is presented in **Table 2**.

Table 2. In hospital outcomes of the studied population

	Group A n = 364		Group B n = 270		P- Value
	No.	%	No.	%	
In-hospital mortality	17	4.6	20	7.4	0.036 *
Re-infarction	28	7.7	33	12.2	0.041 *
Need for revascularization	39	10.7	43	15.9	0.046 *
Heart Failure	117	32.1	96	35.6	0.258
CVS	20	5.5	10	3.7	0.022
Bleeding	39	10.7	30	11.1	0.511

p value for comparing between the two studied groups. *: Statistically significant at $p \leq 0.05$.

Duration of hospitalization

Patients in Group B experienced significantly longer hospital stays compared with those in Group A (6.85 ± 4.22 vs. 3.5 ± 2.3 days, $p = 0.0025$).

Discussion

Key Findings: The COVID-19 pandemic has disrupted multiple aspects of healthcare delivery, including care for patients with cardiovascular disease and acute coronary syndromes [4]. This study aimed to assess how the pandemic influenced the management and in-hospital outcomes of STEMI patients undergoing standard PPCI. Our analysis demonstrates that all STEMI patients received PPCI without resorting to fibrinolytic therapy, even in cases highly suspected for COVID-19. However, the overall volume of PPCI procedures decreased, and interventions were delayed compared with pre-pandemic 2019 controls. Hospitalization was prolonged, and adverse outcomes such as recurrent myocardial infarction, need for coronary revascularization, and increased in-hospital

mortality were more frequent. In contrast, rates of heart failure and bleeding remained comparable to those observed in the previous year.

Comparison with Other Studies: Our findings indicate a clear shift in STEMI management during the COVID-19 period, characterized by delayed presentation and intervention. The delayed hospital presentation largely reflects patients' reluctance to seek care due to fear of viral exposure. This trend aligns with international reports: Hun Shing Kwok *et al.* observed a marked decline in PPCI procedures in the UK during lockdowns [18], Dingcheng Xiang *et al.* reported a 62% reduction in China [19], and a multi-center survey in Spain noted a 40% decrease across 73 centers [20]. Procedure delays were largely attributable to pre-procedural COVID-19 screening and, in some high-risk cases, additional investigations such as chest CT scans.

The observed increase in in-hospital mortality during the pandemic is consistent with the findings of Dingcheng Xiang *et al.* [19] but differs from reports by Hun Shing Kwok *et al.* [18]. Furthermore, we noted higher rates of recurrent infarction, repeat revascularization, and a doubling of hospital stay length during the pandemic, while the incidence of heart failure, stroke, and bleeding remained similar. These observations largely mirror those reported by Dingcheng Xiang *et al.* [19] but contradict the findings of Hun Shing Kwok *et al.* [18], who described reduced hospitalization durations.

Overall, the global impact of COVID-19 on STEMI care appears most pronounced during the acute phase, with delays in presentation, fewer PPCI cases, and prolonged intervention times. While patient-related factors primarily explain delayed presentation, hospital-driven factors, such as the timing of procedures, depend on the individual clinical scenario. Other clinical outcomes are further influenced by patients' comorbidities and the severity of COVID-19 infection, which vary between individuals.

Study Limitations: Several limitations should be noted. The study population consisted of patients referred to ICC by local cardiologists or hospitals, which may limit the generalizability of the findings. The analysis focused solely on in-hospital outcomes, with no long-term follow-up. Although patients originated from different sources, all procedures and management were conducted at a single center, which may influence the observed results.

Conclusions

In conclusion, the COVID-19 pandemic was associated with a marked reduction in the number of STEMI patients treated with PPCI at ICC-Egypt, delayed procedures, increased in-hospital mortality, higher rates of recurrent myocardial infarction and repeat revascularization, and prolonged hospitalization. However, the rates of heart

failure, stroke, and bleeding remained comparable to pre-pandemic levels.

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