ORIGINAL ARTICLE

A Comparison between Pre-outbreak and Outbreak of Coronavirus Disease (COVID-19) in Patients with ST-segment Elevation Myocardial Infarction: A Thailand Single-center Study

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Background: Coronavirus disease 2019 (COVID-19) pandemic hit the world hard in 2020. Strict heath care measures were enforced and created obstacles for ST-segment elevation myocardial infarction (STEMI) management.

Objective: To study an effect of an outbreak of COVID-19 on STEMI care and outcomes.

Materials and Methods: Consecutive STEMI patients from Khon Kaen University Cardiac Catheterization Registry (KKUCCR) and Acute Coronary Syndrome (ACS) registry were used as pre-outbreak (May 2018 to July 2019) and outbreak (April 2020 to June 2020) patients, respectively. Comparison of patients' characteristics, management, and outcomes of STEMI were conducted.

Results: 612 and 118 patients were enrolled into pre-outbreak and outbreak period, respectively. Between pre-outbreak and outbreak period, average number of patients per month was similar (40.8 vs. 39.3, p=0.76), while time from chest pain onset to first medical contact (FMC), time from FMC to wire crossing in primary percutaneous coronary intervention (PCI), and time from PCI center arrival to catheterization laboratory were significantly delayed during outbreak period (167.6±211.3 vs. 272.6±447.8 min, p=0.001, 427.9±283.3 vs. 528.8±535.4 min, p=0.04, and 90.3±141.0 vs. 159.4±419.9 min, p=0.002, respectively). A trend of increase in-hospital mortality was observed during outbreak period (5.7% vs. 10.2%, p=0.07), whereas a significant increase in all-cause death and cardiovascular death at 1 year were demonstrated in STEMI patients presented during an outbreak (8.8% vs. 22.0%, p<0.001, and 6.5% vs. 12.7%, p=0.02, respectively).

Conclusion: During early wave of COVID-19 outbreak, incidence of STEMI was not changed, however, patients' delay and system's delay were obvious, and mortality of STEMI patients was increased.

Keywords: COVID-19; ST-segment elevation myocardial infarction; Mortality

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ST-segment elevation myocardial infarction (STEMI) is a global major cardiovascular (CV) emergency which its management must be count as unit of minute. Delay of any treatment, especially coronary revascularization, negatively affected patient's survival both in short and long term[1-3]. The prompt institution of coronary revascularization, either with systemic fibrinolysis or percutaneous coronary intervention (PCI), was hence being the cornerstone of treatment concept and was strongly addressed among international practice guidelines[4-6].

Coronavirus disease 2019 (COVID-19) was firstly erupted at Wuhan district, China, in December 2019, and rapidly spread worldwide in the year later. To curb the contagion, many public and health care system measures have been officially implemented in many countries, and as the fear of pandemic, patients were also refrained from seeking medical attention[7-9], which all those changes eventually affected management of STEMI and potentially worsen patients' outcome. To date, a significant drop of STEMI cases have been observing among centers around the world[7,8,10-15], and multiple reports have been demonstrating a significant delay in STEMI patients' presentation[9,11,16-21] and a significant decrease of PCI procedures for STEMI

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during the pandemic[7,10,22-24]. Such undesired changes in patterns of STEMI further caused detrimental effect on injured myocardium, which several studies had indicated higher troponin levels, lower left ventricular ejection fraction (LVEF), higher thrombus burden, increased infarct size and extent of microvascular obstruction, and increased incidence of cardiac mechanical complication in patients with STEMI presented during the pandemic[9,19,25-29]. The effect of the pandemic on mortality of patients with STEMI, however, was discrepant. Some reports observed no effect of the pandemic on mortality[16,17,21,27,30,31], whereas some reports found significant excess of mortality during the pandemic[10,11,32]. A meta-analysis of 10 studies did not showed a significant impact of an outbreak on in-hospital mortality[33], though another meta-analysis of 32 studies denoted an increased in-hospital mortality of patients with STEMI during the pandemic, particularly in the Eastern and low-to-middle income countries[34].

As practices of STEMI could be differed across countries, and health care system adaptations and response behavior of patients to the pandemic were varied across regions. We therefore aimed to study the effects of COVID-19 outbreak on STEMI care and outcomes in our local setting.

Materials and Methods

Study design, population, and data collection

We conducted a retrospective analysis by comparison of data of patients with STEMI between prior and during the outbreak at Queen Sirikit Heart Center of the Northeast and Srinagarind Hospital, a tertiary heart center located in the Northeastern of Thailand. The pre-outbreak data was derived from a Khon Kaen University Cardiac Catheterization Registry (KKUCCR) database, which consecutive patients with coronary artery disease who presented at our center were enrolled between May 2018 to July 2019 (enrollment termination). The outbreak data was derived from a Acute Coronary Syndrome (ACS) registry, which is being another our own local registry where all patients with ACS who presented at our center since December 2018 were consecutively enrolled. A period between April 2020 to June 2020 (3 months) was selected as a representative for an outbreak period as Thailand entered its first wave of COVID-19 outbreak at end of March 2020, which multiple public health and social measures were officially enforced on April 2020 and were phased out shortly on July 2020 as the outbreak was effectively controlled and the economic constraints deemed unbearable[35]. Although July 2020 was still within a period of measures enforcement, however, we did not included this period into an analysis because many measures were canceled by this month and health care system had practically returned to its normal activity and capacity since early of July 2020. Diagnosis of STEMI was established by cardiologist according to the Fourth Universal Definition of Acute Myocardial Infarction[36].

Baseline clinical and laboratory information, pattern of presentation, time delay in each step of care, management strategies, and in-hospital outcomes of patients were collected after an admission using a specific case record form in both registries. Data entry of KKUCCR and ACS registry were monitored and audited by SK and BP, respectively. One-year outcomes including mortality were reviewed from medical record and searched from national death clarification database. Final data cleansing was performed by SP, BP, and CW. We comparatively analyzed the data between pre-outbreak and outbreak period to explore an impact of COVID-19 outbreak in Thailand into 4 dimensions, i.e., (i) number and characteristics of patients, (ii) time delay of presentation and treatment, (iii) management strategies, and (iv) in-hospital and 1-year mortality and other clinical outcomes. The study was approved by the Khon Kaen University Ethics Committee for Human Research (HE641181).

Statistical analysis

Categorical variables are presented as frequency (percentage) and compared by Chi-square test. Continuous variables are presented as mean ± standard deviation (SD) for symmetrical distributions and median (interquartile range [IQR]) for skewed distributions and compared by Student's t-test or Wilcoxon Rank Sum test, respectively. All statistical analysis was performed using STATA software version 10.0 (STATA, Texas, USA). The p-value less than 0.05 was considered statistical significance.

Results

A total of 612 patients and 118 patients were recruited into pre-outbreak and outbreak period, respectively. Comparing between pre-outbreak and outbreak period, average number of patients per month (40.8 vs. 39.3, p=0.76), percentage of referral patients (95.8% vs. 96.6%, p=0.66), and proportion of female patients (25.5% vs. 23.7%, p=0.68) were quite similar between both periods, however, patients during outbreak presented with few years of younger age but statistically significant (63.8±12.0 vs. 60.4±12.6 years, p=0.005). Type of STEMI, LVEF, and high sensitivity cardiac troponin were not statistically different between both periods. Among patients during outbreak, over one-third (36.4%) presented with Killip class III/IV, and almost one-tenth presented with unstable ventricular tachycardia (VT) or ventricular fibrillation (VF) and receiving cardiopulmonary resuscitation (CPR). Traditional CV risk factors were mostly similar between both groups, except statistically higher non-smoker patients and

statistically lower ex-smoker patients and prior myocardial infarction (MI) in patients during outbreak. Baseline characteristics of patients were presented in Table 1.

Table 2. presents the time in patients' presentation, transferring, and PCI performing. Comparing with pre-outbreak period, STEMI patients who presented during outbreak period had significant longer time from chest pain onset to first medical contact (FMC) (167.6±211.3 vs. 272.6±447.8 min, p=0.01), time from FMC to wire crossing in primary PCI (427.9±283.3 vs. 528.8±535.4 min, p=0.04), and time from PCI center arrival to catheterization laboratory in primary PCI (90.3±141.0 vs. 159.4±419.9 min, p=0.002), but significant shorter time from FMC to thrombolysis (91.8±102.8 vs. 76.5±49.8 min, p=0.01) and

Table 1. Characteristics of patients with ST-segment elevation myocardial infarction categorized by outbreak period of coronavirus disease (COVID-19)

Characteristic	Pre-outbreak (n=612)	Outbreak (n=118)	p-value
Patients per month (average number)	40.8	39.3	0.76
Referral patients – n (%)	586 (95.8)	114 (96.6)	0.66
Age – (year)	63.8±12.0	60.4±12.6	0.005
Female sex – n (%)	156 (25.5)	28 (23.7)	0.68
BMI – (kg/m^2)	23.7±4.1	23.7±4.8	>0.999
Heart rate – (bpm)	82.2±19.3	85.4±20.9	0.12
SBP – (mmHg)	129.4±22.8	130.5±24.8	0.42
DBP – (mmHg)	77.6±17.2	78.4±16.8	0.63
Smoking status – n (%)			
Current smoker	250 (40.9)	47 (39.8)	0.83
Ex-smoker	136 (22.2)	3 (2.5)	<0.001
Non-smoker	224 (36.6)	68 (57.6)	<0.001
Comorbidities – n (%)			
Hypertension	243 (39.8)	35 (29.7)	0.03
Diabetes	169 (27.8)	43 (36.4)	0.053
Dyslipidemia	191 (31.3)	31 (26.3)	0.28
CVA	24 (3.9)	2 (1.7)	0.23
CKD	40 (6.6)	5 (4.2)	0.34
Prior MI	133 (21.9)	6 (5.1)	<0.001
LVEF – (%)	48.2±12.6	47.7±13.4	0.70
High sensitivity cardiac troponin T – (ng/L)	1,476 (438, 3,485)	1,623 (509, 4,621)	0.47
eGFR – (ml/min/1.73 m^2)	70.7±28.9	75.4±27.7	0.09
Hemoglobin – (g/dl)	11.9±2.5	12.9±2.5	<0.001
HbA1C – (%)	7.1±7.7	7.0±2.4	0.25
LDL-C – (mg/dL)	122.7±47.4	125.8±50.0	0.53
STEMI diagnosis – n (%)			
Anterior wall	314 (51.3)	57 (48.3)	0.55
Inferior wall	261 (42.7)	56 (47.5)	0.33
Lateral wall	6 (1.0)	2 (1.7)	0.49
Posterior wall	12 (2.0)	2 (1.7)	0.84
Other	19 (3.1)	1 (0.9)	0.16
Killip class – n (%)			
I	NA	73 (61.9)	
II	NA	2 (1.7)	
III	NA	13 (11.0)	
IV	NA	30 (25.4)	
Unstable VT/VF – n (%)	NA	10 (8.5)	
Post CPR – n (%)	NA	11 (9.3)	

BMI=body mass index; CKD=chronic kidney disease; CPR=cardiopulmonary resuscitation; CVA=cardiovascular accident; DBP=diastolic blood pressure; eGFR=estimated glomerular filtration rate; LDL-C=low-density lipoprotein cholesterol; LVEF=left ventricular ejection fraction; MI=myocardial infarction; NA=not applicable; SBP=systolic blood pressure; STEMI=ST-segment elevation myocardial infarction; VF=ventricular fibrillation; VT=ventricular tachycardia

time from PCI center arrival to catheterization laboratory in rescue PCI (101.1±140.5 vs. 58.3±24.8 min, p<0.001). Interestingly, there were trends of delay of time from FMC to PCI center arrival and time from FMC to wire crossing in rescue PCI in patients during outbreak, and time from FMC to electrocardiography (ECG) was 15.0±28.6 minutes during outbreak period, which is late than acceptable standard of within 10 minutes[5].

Table 3. presents treatment. Considering mode of revascularization, thrombolysis was given in a similar proportion between pre-outbreak and outbreak periods (57.8% vs. 51.7%, p=0.21), however, proportion of PCI, both primary and rescue, were significantly higher during outbreak period (32.7% vs. 48.3%, p=0.001, and 30.1% vs. 36.1%, p=0.01, respectively). Use of oral antiplatelet was comparable between both periods, but use of glycoprotein IIb/IIIa inhibitor was significantly higher during pre-outbreak period (11.7% vs. 4.3%, p=0.01). Considering PCI procedures, there was no significant difference regarding vascular access (radial vs. femoral artery), number of vessels stented, and number of stent use between both groups, which less than 2 stents were implanted in more than 90% of patients. Procedural success of PCI was similar, while procedural complications of PCI was significantly lower in patients during outbreak (16.0% vs. 5.7%, p=0.005). Intra-aortic balloon pump (IABP) insertion, however, was numerically higher in patients during outbreak (15% vs. 19.5%, p=0.22).

Outcomes of patients are presented in Table 4. Regarding mortality between pre-outbreak and outbreak period, patients with STEMI who presented during outbreak had numerically higher in-hospital mortality rate (5.7% vs. 10.2%, p=0.07), and significantly higher rate of all-cause death and CV death at 1 year (8.8% vs. 22.0%, p<0.001, and 6.5% vs. 12.7%, p=0.02, respectively). The occurrences of recurrent MI, heart failure admission, stroke, and major bleeding were similar between both groups. Interestingly, duration of hospitalization was significantly shorter during outbreak period (5 [3, 8] vs. 3 [2, 5] days, p<0.001).

Discussion

The present study denoted landscapes of STEMI presentation, management, and outcome during the COVID-19 initial outbreak era by comparison with a contemporary registry which finished just a year before an outbreak. Both registries were conducted at only one center in Thailand, which nature of patients with STEMI were considered steady, therefore, any changes in outcome that occurred during the outbreak period are likely to be an effect of changes in management pathway during the pandemic. As expected, we found many delays along the system of STEMI management, starting with delay of patient's itself in presentation to medical center, continuing with delay of first medical center in ECG execution and transferring patient to PCI center, and last with delay of PCI center in performing PCI, especially primary PCI. And probably as resulted, mortality of patients is higher than usual, with mortality rate of 10.2% during hospitalization and 22.0% within one year, even though no compromise on pursuing of revascularization and no difference in medical therapy and PCI strategies.

Number of STEMI patients presenting to our center is quite similar at about 40 patients per month between pre-outbreak and outbreak era, which is contrary to many other regions around the world that seeing a drop of number of STEMI patients during the pandemic[12,14,15,32,37,38]. It is understandable that strict social containment measures which were universally applied in many countries could strongly affect patients' approach to treatment and then decrease the number of STEMI hospitalization. This finding surprised us, and we could not truly give a good explanation for this phenomenon. Although there is a possibility that patients with COVID-19 had a prone of inflammation and hypercoagulation which could leading to acute MI[39], however, the incidence of COVID-19 during an early outbreak in Thailand was very low[40] and such number

Table 2. Time in patients' presentation, transfer, and PCI performing

Characteristic	Pre-outbreak (n=612)	Outbreak (n=118)	p-value
Time from chest pain onset to FMC – (minute)	167.6±211.3	272.6±447.8	0.01
Time from FMC to ECG – (minute)	NA	15.0±28.6	
Time from FMC to thrombolysis – (minute)	91.8±102.8	76.5±49.8	0.01
Time from FMC to PCI center arrival – (minute)	339.3±198.3	1,112.2±1,518	0.09
Time from FMC to wire crossing in primary PCI – (minute)	427.9±283.3	528.8+535.4	0.04
Time from FMC to wire crossing in rescue PCI – (minute)	461.4±209.2	590.7±763.5	0.07
Time from PCI center arrival to catheterization laboratory – (minute)	227.2±332.9	542.0±1053.8	0.14
Primary PCI	90.3±141.0	159.4±419.9	0.002
Rescue PCI	101.1±140.5	58.3±24.8	<0.001

ECG=electrocardiography; FMC=first medical contact; NA=not applicable; PCI=percutaneous coronary intervention

Table 3. Treatment

Variable	Pre-outbreak (n=612)	Outbreak (n=118)	p-value
Patient receiving revascularization – n (%)			
Thrombolysis	354 (57.8)	61 (51.7)	0.21
Primary PCI	200 (32.7)	57 (48.3)	0.001
Rescue PCI	184 (30.1)	22 (36.1)	0.01
CABG	18 (2.9)	5 (4.2)	0.46
Fibrinolysis – n (%)			
Streptokinase	353 (99.7)	60 (98.4)	0.17
Alteplase	1 (0.3)	1 (1.6)	0.19
Aspirin – n (%)	592 (99.2)	114 (96.6)	0.94
$P2Y_{12}$ inhibitor – n (%)			
Clopidogrel	588 (98.5)	118 (100.0)	0.02
Prasugrel	5 (0.8)	0	0.32
Ticagrelor	47 (7.9)	0	0.001
GP IIb/IIIa inhibitor – n (%)	70 (11.7)	5 (4.3)	0.01
Initial vascular access* – n (%)			
Radial artery	380 (63.7)	69 (59.0)	0.45
Femoral artery	237 (39.7)	49 (41.9)	0.56
Number of vessels stented* – n (%)			
1	451 (97.0)	84 (95.5)	0.57
2	14 (3.0)	3 (3.4)	0.86
3	0	1 (1.1)	0.02
Number of stent use* – n (%)			
1	273 (63.9)	58 (65.9)	0.77
2	120 (28.1)	23 (26.1)	0.84
3	26 (6.1)	6 (6.8)	0.94
4	7 (1.6)	0	0.24
5	0	1 (1.1)	0.02
6	1 (0.2)	0	0.66
IABP implantation – n (%)	92 (15.0)	23 (19.5)	0.22
Procedural success of PCI* – n (%)	493 (97.6)	88 (100.0)	0.14
Procedural complications of PCI* – n (%)	81 (16.0)	5 (5.7)	0.005

*Among patients who underwent percutaneous coronary intervention.

CABG=coronary artery bypass graft; GP=glycoprotein; IABP=intra-aortic balloon pump; PCI=percutaneous coronary intervention

Table 4. In-hospital and 1-year outcomes

Variable	Pre-outbreak (n=612)	Outbreak (n=118)	p-value
In-hospital mortality – n (%)	35 (5.7)	12 (10.2)	0.07
Duration of hospitalization* (day)	5 (3,8)	3 (2,5)	<0.001
One-year outcomes – n (%)			
All-cause death	54 (8.8)	26 (22.0)	<0.001
CV death	40 (6.5)	15 (12.7)	0.02
Recurrent MI	15 (2.5)	3 (2.5)	0.95
Heart failure admission	20 (3.3)	1 (0.9)	0.14
Stroke	6 (1.0)	1 (0.9)	0.89
Major bleeding	2 (0.3)	1 (0.9)	0.41

* Data is presented as median (interquartile range).

CV=cardiovascular; MI=myocardial infarction

was seemingly not able to rebalance the number of STEMI patients to be equal as we have found. As the pandemic itself should not alter the true incidence of STEMI, therefore, we hypothesized that it probably was a strong and relentless

enthusiasm of a long-run STEMI network at our region that kept maintaining the number of STEMI hospitalization in the present study.

In term of time to treatment, we observed a significant delay in every step of STEMI care during an outbreak since the presentation of patient to first medical center through performing PCI. All those delays were unavoidable and definitely resulted from health care measures which limited patients' approach to medical attention and restricted patients' transfer both within and between medical center, and this finding was totally in line with other studies throughout the globe[11,17,18,21,34,41]. Delay of patients' presentation could also being a result from fear of acquiring COVID-19 by patients while seeking medical attention which forced them to avoid early presentation as usual[9]. Delay of first medical center was depicted by late diagnosis, which reflected from late-than-target ECG execution, and a large numerically late in time from FMC to PCI center arrival, and delay of PCI center was depicted by late in time from catheterization laboratory arrival to primary PCI. Considering the delay in our system during an outbreak, the late in time from FMC to PCI center arrival, although being non-statistically significant, was the largest late (difference of mean time of 773 minutes) and should be considered as clinically significant difference. This late in patients' transfer between first center and PCI center indicated a severe limitation or restriction of transfer process and should be focused as a priority issue for improving STEMI care during pandemic. Interestingly, there were statistically significant hastening in thrombolysis administration and catheterization laboratory transfer in rescue PCI found in our study. It was not quite clear to us why these pictures happened, the possible explanation could be physicians tended to locally use thrombolysis rather than transfer patient out to PCI center for PCI during an outbreak, therefore the decision could be made quicker, and thrombolysis was then infused earlier. And as in our own PCI practice for patients with STEMI who had failed thrombolysis, we were able to activate the "fast track" system, in which the preparation of patients for PCI is more accelerated and PCI could be performed more quickly, maybe such system was fully activated during an outbreak than before and leading to a shorter catheterization laboratory transfer for rescue PCI in consequence.

Fortunately, there was no restriction in any armamentarium for STEMI treatment during an outbreak, therefore there was no clinical difference in term of medical or interventional therapy in our study. However, the mortality of STEMI was dramatically worse among patients who presented during an outbreak, which the mortality increased almost 2-fold during hospitalization (5.7% vs. 10.2%, p=0.07) and over 2-fold for 1 year (8.8% vs. 22.0%, p<0.001) after STEMI. Considering there was no clinically significant difference regarding type of STEMI, atherosclerotic risk factors, LVEF, medical therapy, and interventional therapy between pre-outbreak and outbreak patients, therefore, we postulated that the delay in patients' presentation and STEMI care pathways which we had mentioned earlier would be a prominent contributing factor for an increase in mortality. A relationship between prolonged myocardial ischemic time and adverse myocardial function has been acknowledged for over 50 years[42], and association between system delay and mortality in patients with STEMI treated with primary PCI was clearly demonstrated[3]. There was also a recent study demonstrated a relationship between increase myocardial damage measured by cardiac magnetic resonance image in STEMI patients who presented during the COVID-19 pandemic and public health restrictions[29]. As such, all those evidences gave favor for our assumption mentioned above, and our findings were align with many other studies[11,19,32,37,38], however, there are also many studies which found no statistically significant increase in mortality of STEMI patients during COVID-19 pandemic[16,17,21,27,30,33,43]. The ambiguous association between COVID-19 pandemic and mortality of STEMI patients around the globe might be a result of varying of patients' characteristics and attitude, STEMI care pathway, and detailed medical and interventional therapy across each region. Interestingly, a meta-analysis showed significant increase in mortality of STEMI patients during COVID-19 pandemic among countries with low- to middle-income, whereas an insignificant trend of increase mortality was observed among countries with high-income[34]. Of note, duration of hospitalization was significantly shorter during an outbreak, which this could be an impact from health care restrictions and could probably effect quality of care and resulted into poor clinical outcome.

A recent another single-center study from Thailand which longer duration of outbreak was designated showed a similar delay in patients' presentation and STEMI care system during an outbreak like our findings, however, they found a decline of number of STEMI patients and more use of IABP during pandemic, while no significant difference in in-hospital mortality existed[43], which were contrary to our results.

Limitations are contained in our study. The most important one was being a single center, which selective nature of patients' characteristics, network of STEMI care, available medications and devices, and preference and expertise of physicians would inevitably bias the results. The number of STEMI patients during an outbreak might be less and seemingly incomparable with another group, however, as we intended to study an impact of pandemic during its maximal effect on patients' attitude and health

care restrictions, then number of patients among a 3-month duration was selected. Some information regarding severity of STEMI (i.e., Killip class, VT/VF, and CPR) were missed among pre-outbreak group and this could obscure the comparative picture of severity of STEMI which may be changed during pandemic. And finally, data of medication during follow-up was missed, which difference of some mandatory medications could probably affect a one-year mortality, however, as there was no enforce of health restriction related with medical therapy, we therefore believed that there would have no significant difference regarding this issue. Our study has a strong point that all consecutive patients were enrolled, the number of patients were sizable, and data were collected in prospective manner.

Conclusion

Incidence and characteristics of STEMI patients were not significantly changed during COVID-19 outbreak. The management of STEMI with either medication or intervention during an outbreak were also kept standard and comparable with pre-outbreak period. However, there was prominent and significant delay of patients' presentation and patients' transfer, both between first medical center and PCI center and within PCI center itself, especially in primary PCI, which finally led to delay time use for optimal revascularization. An insignificant trend of increased mortality and significant increase in one-year all cause mortality and CV mortality were observed among STEMI patients who presented during an outbreak. Our study urged the importance of re-education for patient and society about value of early presentation when one's having angina and stimulated for an appropriate adjustment of health care system in balancing between delay of patients' transfer and curbing measures for COVID-19, with an aim to shorten the myocardial ischemic time and improve chance of STEMI survival.

What is already known on this topic?

Number of patients with ST-segment elevation myocardial infarction (STEMI) and percutaneous coronary intervention (PCI) procedure were universally dropped during COVID-19 pandemic.

Patient delay and system delay were globally prominent during COVID-19 pandemic.

Impact of COVID-19 pandemic on mortality of patients with STEMI, however, was discrepant across the globe.

What this study adds?

Incidence of patients with STEMI was unchanged during the early wave of COVID-19 pandemic, this could indicate the difference of STEMI network adaptation between each region.

Delay of STEMI patients' presentation and transfer were globally uniform and seemingly unavoidable.

Mortality of patients with STEMI during COVID-19 pandemic was increased, with insignificant trend for in-hospital mortality but significantly increased at 1-year.

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Conflicts of interest

The authors declare no conflict of interest.

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