Impact of COVID-19 on Acute MI and Percutaneous Coronary Intervention Rates and Outcomes in South East Asia and the Middle East

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Abstract

Background: Previous studies have reported mixed findings regarding the effects of COVID-19 on percutaneous coronary intervention (PCI) and acute MI (AMI) procedural volumes and case fatalities, as well as on ST-elevation MI (STEMI) door-to-balloon time (DTB). This study characterised the effects of COVID-19 on AMI and PCI volumes and mortality outcomes in countries from Asia and the Middle East, which faced repeated waves of COVID-19. **Methods:** Pooled data on AMI and PCI case volumes were collected in 4-weekly blocks from Malaysia, Singapore and Abu Dhabi from 2019 (pre-COVID-19) and 2020 (during COVID-19). These were compared against reported COVID-19 case numbers. Case fatality rates, STEMI patient demographics and STEMI DTB times were compared between the pre- and during COVID-19 periods. **Results:** During the COVID-19 pandemic, there was a comparative reduction in non-STEMI (NSTEMI) cases in Singapore (from 814 to 722; $p=0.025$) and Malaysia (from 925 to 604; $p<0.001$), but not in Abu Dhabi (from 144 to 188; $p=0.010$). PCI volumes fell significantly in Singapore (from 13,089 to 11,449; $p=0.020$), but not in Malaysia or Abu Dhabi. STEMI volume remained similar before and during COVID-19. There were no significant differences in in-hospital mortality for NSTEMI, STEMI or PCI between the two periods. **Conclusion:** COVID-19 resulted in a fall in NSTEMI and PCI cases, potentially as a result of patients deferring contact with healthcare institutions. With appropriate protocols and systems, it is possible to provide coronary intervention services in the middle of a pandemic without compromising on mortality or DTB outcomes.

Keywords

COVID-19, acute MI, percutaneous coronary intervention, case volume, mortality, door-to-balloon time

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Since the outbreak of the severe acute respiratory syndrome coronavirus 2 pandemic in 2019, COVID-19 has spread across the globe, resulting in millions of deaths worldwide. Beyond an immediate impact on mortality and morbidity, this pandemic has also had secondary ramifications for the provision of healthcare as hospitals change existing workflows to accommodate the screening and treatment of COVID and governments impose lockdown measures that directly and indirectly affect patients' presentation to hospitals.

Studies have been published about the effect of the COVID-19 pandemic on procedural volumes of elective percutaneous coronary intervention (PCI), as well as on the presentations and outcomes of acute MI (AMI).¹⁻⁵ Many of these studies only capture the perspective of a single centre in a

particular country. Furthermore, study findings are mixed, with some studies reporting a decrease in non-ST segment elevation MI (NSTEMI) or ST-elevation MI (STEMI) presentations since the onset of the pandemic, and others finding no significant difference, particularly in the STEMI caseload.¹⁻⁵ Similarly, reported effects on door-to-balloon (DTB) time and mortality outcomes are mixed.¹

The aim of this study was to investigate the effects of the COVID-19 pandemic on AMI and PCI rates in countries from Asia and the Middle East to gain an insight into the burden COVID-19 was placing on cardiovascular care. This research is especially pertinent because many of these countries are facing repeated waves of COVID-19, and lessons drawn from earlier experiences will be instructive in preparing for future outbreaks.

Figure 1: Acute MI Case Volumes Compared Against COVID-19 Case Numbers and National Lockdown Measures

The vertical dotted lines on the plots represent the respective lockdown periods in Singapore and Malaysia, and the daytime partial curfew implemented in Abu Dhabi. NSTEMI = non-ST segment elevation MI; STEMI = ST-elevation MI.

Methods

Member countries from the Asian Pacific Society of Cardiology were invited to submit pooled data on cases with discharge diagnoses of AMI or PCI, as defined by prespecified ICD codes. Records for admissions for AMI were further subdivided into diagnoses of NSTEMI and STEMI. In-hospital case fatality data were collected for each of these admissions.

In addition, data on patient demographics, comorbidities and DTB time were collected for STEMI admissions. We chose STEMI cases for closer analysis because STEMI is a well-defined clinical entity, with established guidelines around the diagnosis and management of the condition, thus making it a good substrate for comparison of patient profiles before and during the COVID-19 pandemic.

Three centres responded to the call for data: the National Heart Association of Malaysia, which indexes all PCI and AMI data in Malaysia; the National Heart Centre Singapore, a tertiary hospital with the highest PCI case volume in Singapore; and the Cleveland Clinic Abu Dhabi, a private tertiary hospital in Abu Dhabi. AMI and PCI case volumes were reported in 4-weekly blocks and plotted against COVID-19 case numbers in each respective country for the corresponding time block (Figures 1 and 2).

Statistical Analysis

Statistical significance was set at two-tailed $p < 0.05$. Continuous variables are presented as the median with interquartile range (IQR) and categorical

variables are presented as frequencies and percentages. Comparisons between the pre- and during COVID-19 periods were made using χ^2 -squared or Fisher exact tests, as appropriate, for categorical variables and two-sample t -tests or the Kruskal–Wallis test for continuous variables. The relative risk of mortality was calculated based on 2×2 contingency tables. Percentage changes were calculated by comparing the admissions and procedural volumes of the respective 4-week blocks for 2019 with the same period in 2020.

All statistical analyses were conducted using Stata version 16 (StataCorp).

Results

Acute MI

Overall, 3,661 patients were admitted for AMI during the pre-COVID-19 period, compared with 2,968 during the COVID-19 period ($p < 0.001$). Although there was no difference in the number of STEMI admissions before and during the COVID-19 period (1,420 versus 1,233; $p = 0.081$), there was a significant reduction in NSTEMI admissions (1,883 versus 1,514; $p < 0.001$; Tables 1 and 2).

Looking at data from individual countries, both Singapore and Malaysia experienced a reduction in total AMI admissions, driven primarily by a reduction in NSTEMI presentations. In Singapore, NSTEMI cases fell from 814 before the pandemic to 722 during the pandemic ($p = 0.025$). Similarly, in Malaysia, NSTEMI cases fell from 925 before the pandemic to 604

Figure 2: Percutaneous Coronary Intervention Case Volumes Compared Against COVID-19 Case Numbers and National Lockdown Measures

The vertical dotted lines on the plots represent the respective lockdown periods in Singapore and Malaysia, and the daytime partial curfew implemented in Abu Dhabi. PCI = percutaneous coronary intervention.

during the pandemic ($p < 0.001$). However, in Abu Dhabi, there was a significant increase in NSTEMI cases (144 to 188; $p = 0.010$). There was no significant difference in STEMI cases from before to during the pandemic in any of the three countries.

Patients admitted with STEMI during the COVID-19 period, compared with those admitted prior to the pandemic, were less likely to have diabetes (35.0% versus 38.7%; $p = 0.030$), more likely to have dyslipidaemia (50.7% versus 41.2%; $p < 0.001$), more likely to have had prior coronary artery bypass grafting (1.9% versus 0.8%; $p = 0.004$) and more likely to have had prior coronary artery disease or PCI (16.6% versus 10.9%; $p < 0.001$). Overall, there was a significant decrease in the proportion of cases achieving a DTB time of ≤ 90 minutes during the COVID-19 period (59.89% versus 76.81%; $p < 0.001$) (Table 3).

In Malaysia, there was a significant reduction in proportion of cases with a DTB time ≤ 90 minutes during the pandemic (39.00% versus 71.21%; $p < 0.001$). However, there was no difference in the proportion of cases with a DTB time ≤ 90 minutes in Singapore and Abu Dhabi with $> 95\%$ of cases having a DTB ≤ 90 minutes in both countries. There was no significant difference before and during COVID-19 in in-hospital mortality for STEMI patients (5.49% versus 4.62%; $p = 0.309$) or in in-hospital mortality for NSTEMI patients (3.03% versus 3.43%; $p = 0.503$). Similarly, individual country analysis did not yield any significant differences in case fatality rates for STEMI or NSTEMI patients before and during COVID-19 (Table 4).

PCI Volume

Overall, there was a significant decrease in PCI cases from before to during the COVID-19 period (13,089 versus 11,449; $p = 0.020$). This was driven mostly by data from Singapore, where the number of PCI cases decreased from 2,902 before the pandemic to 2,107 during the pandemic ($p < 0.001$). In contrast, the PCI caseload in Malaysia and Abu Dhabi remained relatively constant ($p > 0.05$). Overall, there was no significant difference in the case fatality rate from before to during the COVID-19 pandemic (1.55% versus 1.44%, respectively; $p = 0.480$).

Discussion

Data pertaining to the impact of COVID-19 on cases of AMI are varied. Several centres have reported a decrease in admissions during the pandemic,^{1,2,6} whereas others have found no significant difference compared with pre-COVID-19 levels.⁵ With regard to the type of MI, most studies have shown a decrease in NSTEMI admissions during the COVID-19 pandemic, but mixed results pertaining to STEMI presentations.^{3,7}

Similarly, in the present study there was a decrease in NSTEMI admissions, but we did not find any significant difference in STEMI presentations between the two periods. It is conceivable that STEMI patients experience more severe symptoms that will push them to seek medical attention. Furthermore, they will also have distinct ECG abnormalities that prompt urgent referral to tertiary centres by primary care or emergency medical services. This stands in contrast to the symptoms in NSTEMI, which may

Table 1: Comparison of Case Volumes in Singapore, Malaysia and Abu Dhabi Before and During the COVID-19 Pandemic

	Total No. Cases 2019–2020	Before COVID-19		During COVID-19		p-value (K-W test)
		Total No. Cases	No. Cases per 4-week block, Median (IQR)	Total No. Cases	No. Cases per 4-week Block, Median (IQR)	
Overall						
Procedural						
PCI cases	24,538	13,089	1,035 (979–1,075)	11,449	976 (779–1,004)	0.020
Primary PCI	1,994	1,247	94 (90–105)	747	53 (43–67)	<0.001
Admissions						
AMI	6,629	3,661	285 (269–297)	2,968	241 (206–253)	<0.001
STEMI	2,653	1,420	107 (101–116)	1,233	102 (80–111)	0.081
NSTEMI	3,397	1,883	145 (140–151)	1,514	124 (109–128)	<0.001
Singapore						
Procedural						
PCI cases	5,009	2,902	221 (213–227)	2,107	159 (137–181)	<0.001
Primary PCI	843	493	39 (34–42)	350	24 (23–28)	0.002
Admissions						
AMI	2,846	1,574	123 (118–128)	1,272	97 (92–102)	<0.001
STEMI	748	408	32 (29–34)	340	25 (21–30)	0.076
NSTEMI	1,536	814	63 (60–66)	722	59 (52–62)	0.025
Malaysia						
Procedural						
PCI cases	18,998	9,928	786 (750–816)	9,070	766 (589–829)	0.522
Primary PCI	1,060	719	58 (51–61)	341	23 (18–37)	<0.001
Admissions						
AMI	3,384	1,916	147 (134–160)	1,468	127 (93–131)	0.001
STEMI	1,838	985	78 (71–82)	853	72 (47–81)	0.317
NSTEMI	1,529	925	71 (66–78)	604	47 (44–53)	<0.001
Abu Dhabi						
Procedural						
PCI cases	531	259	19 (18–21)	272	21 (16–26)	0.699
Primary PCI	91	35	2 (2–3)	56	4 (2–7)	0.052
Admissions						
AMI	399	171	13 (9–16)	228	17 (15–19)	0.016
STEMI	67	27	2 (0–2)	40	2 (2–4)	0.104
NSTEMI	332	144	10 (8–13)	188	14 (13–16)	0.010

AMI = acute MI; IQR = interquartile range; K-W = Kruskal–Wallis; PCI = percutaneous coronary intervention; NSTEMI = non-ST segment elevation MI; STEMI = ST-elevation MI.

be less typical and less intense, such that they are tolerated by patients, who refrain from presenting to hospital for fear of being exposed to COVID-19.

There is high health avoidance behaviour during pandemics, especially when there are unconfirmed beliefs about modes of transmission, increased perceived severity of the outbreak and increased perception of susceptibility.^{8,9} Indeed, nadir levels of NSTEMI and STEMI admissions in Malaysia and Singapore were reached during the respective lockdown periods in each country. In particular, NSTEMI and STEMI admissions in Malaysia were lowest during the period 24 March–20 April 2020, which coincided with the start of the Movement Control Order (18 March–3 May 2020). This is despite the fact that the absolute number of COVID-19 cases

was higher in the latter part of 2020. This suggests that fear surrounding the initial outbreak of a hitherto unknown virus, along with the added psychological burden of a government-imposed curfew, may have been holding patients back from presenting to hospital, despite the fact that they were still allowed to seek medical attention during these lockdown periods.

NSTEMI and STEMI admissions in Abu Dhabi rose in tandem with the number of COVID-19 cases in the country, which is in contrast to data from Singapore and Malaysia. This reflects the impact of local policy, because the Cleveland Clinic Abu Dhabi was designated by the public health authorities as a centre responsible for care of non-COVID-19 conditions. This resulted in NSTEMI and STEMI cases being diverted to this centre.

Table 2: Demographics of Patients Admitted With ST-Elevation MI Before and During the COVID-19 Pandemic

	Overall 2019–2020	Before COVID-19	During COVID-19	p-value
Overall				
No. patients	3,220	1,854	1,366	
Mean (±SD) age (years)	56.9 ± 12.2	56.9 ± 12.1	56.8 ± 12.8	0.819
Male sex	2,744 (85.2)	1,570 (84.7)	1,174 (85.9)	0.318
Diabetes	1,196 (37.1)	718 (38.7)	478 (35.0)	0.030
Hypertension	1,707 (53.0)	984 (53.1)	723 (52.9)	0.935
Dyslipidaemia	1,455 (45.2)	763 (41.2)	692 (50.7)	<0.001
Smoking (current or past)	1,568 (48.7)	861 (46.4)	707 (51.8)	0.003
ESRD on dialysis	55 (1.7)	26 (1.4)	29 (2.1)	0.119
Any CKD	169 (5.2)	90 (4.9)	79 (5.8)	0.243
Prior CABG	40 (1.2)	14 (0.8)	26 (1.9)	0.004
Prior CVA	50 (1.6)	23 (1.2)	27 (2.0)	0.095
Prior known CAD or PCI	429 (13.3)	202 (10.9)	227 (16.6)	<0.001
Singapore				
No. patients	748	408	340	
Mean (±SD) age (years)	62.5 ± 12.4	62.4 ± 12.5	62.6 ± 12.4	0.764
Male sex	601 (80.3)	332 (81.4)	269 (79.1)	0.440
Diabetes	320 (42.8)	181 (44.4)	139 (40.9)	0.338
Hypertension	470 (62.8)	263 (64.5)	207 (60.9)	0.313
Dyslipidaemia	514 (68.7)	270 (66.2)	244 (71.8)	0.101
Smoking (current or past)	382 (51.1)	205 (50.2)	177 (52.1)	0.621
ESRD on dialysis	23 (3.1)	8 (2.0)	15 (4.4)	0.053
Any CKD	109 (14.6)	54 (13.2)	55 (16.2)	0.256
Prior CABG	31 (4.1)	7 (1.7)	24 (7.1)	<0.001
Prior CVA	15 (2.0)	7 (1.7)	8 (2.4)	0.536
Prior known CAD or PCI	237 (31.7)	97 (23.8)	140 (41.2)	<0.001
Malaysia				
No. patients	2,366	1,402	964	
Mean (±SD) age (years)	55.2 (11.6)	55.4 (11.5)	54.9 (11.7)	
Male sex	2,043 (86.3)	1,196 (85.3)	847 (87.9)	0.075
Diabetes	832 (35.2)	518 (36.9)	314 (32.6)	0.029
Hypertension	1,186 (50.1)	699 (49.9)	487 (50.5)	0.752
Dyslipidaemia	883 (37.3)	471 (33.6)	412 (42.7)	<0.001
Smoking (current or past)	1,121 (47.4)	630 (44.9)	491 (50.9)	0.004
ESRD on dialysis	31 (1.3)	18 (1.3)	13 (1.3)	0.892
Any CKD	55 (2.3)	35 (2.5)	20 (2.1)	0.504
Prior CABG	7 (0.3)	6 (0.4)	1 (0.1)	0.154
Prior CVA	29 (1.2)	14 (1.0)	15 (1.6)	0.226
Prior known CAD or PCI	174 (7.4)	99 (7.1)	75 (7.8)	0.510
Abu Dhabi				
No. patients	106	44	62	
Mean (±SD) age (years)	53.1 (11.7)	52.1 (10.6)	53.8 (12.5)	
Male sex	100 (94.3)	42 (95.5)	58 (93.5)	0.676
Diabetes	44 (41.5)	19 (43.2)	25 (40.3)	0.768
Hypertension	51 (48.1)	22 (50.0)	29 (46.8)	0.743
Dyslipidaemia	58 (54.7)	22 (50.0)	36 (58.1)	0.411
Smoking (current or past)	65 (61.3)	26 (59.1)	39 (62.9)	0.691
ESRD on dialysis	1 (0.9)	0 (0.0)	1 (1.6)	0.397

Table 2: Cont.

	Overall 2019–2020	Before COVID-19	During COVID-19	p-value
Abu Dhabi				
Any CKD	5 (4.7)	1 (2.3)	4 (6.5)	0.317
Prior CABG	2 (1.9)	1 (2.3)	1 (1.6)	0.806
Prior CVA	6 (5.7)	2 (4.5)	4 (6.5)	0.676
Prior known CAD or PCI	18 (17.0)	6 (13.6)	12 (19.4)	0.440

Unless indicated otherwise, data are given as n (%). CABG = coronary artery bypass grafting; CAD = coronary artery disease; CKD = chronic kidney disease; CVA = cerebrovascular accident; ESRD = end-stage renal disease; PCI = percutaneous coronary intervention.

Table 3: Number of Patients Meeting a Door-To-Balloon Time of ≤90 min Before and During the COVID-19 Pandemic

	DTB Time ≤90 min		p-value (χ ²)
	Before COVID-19	During COVID-19	
Overall	709 (76.81)	318 (59.89)	<0.001
NHCS	164 (96.47)	129 (96.27)	0.925
NHAM	512 (71.21)	133 (39.00)	<0.001
Abu Dhabi	33 (97.06)	56 (100.00)	0.197

Unless indicated otherwise, data are given as n (%). DTB = door-to-balloon; NHAM = National Heart Association of Malaysia; NHCS = National Heart Centre Singapore.

In this study, the proportion of patients achieving a DTB of ≤90 minutes was reduced in Malaysia, but unchanged in Singapore and Abu Dhabi. Notably, of the three countries, Malaysia pursued a thrombolysis-first strategy, with primary PCI only if the patient was known to be COVID-19-negative or as rescue therapy in the event of failed thrombolysis with medical staff in full personal protective equipment.¹⁰ This would likely explain the difference in DTB time among the three countries. Other studies with similar findings have attributed differences in DTB time to the time taken to perform preadmission screening chest X-rays and to ascertain travel and contact histories and symptomatology in patients whose COVID-19 status is unknown.¹¹ Unfamiliarity of the emergency department (ED) with new workflows may also be a contributing factor, with subsequent recovery in the DTB time towards the later stages of the pandemic.¹² Data from Singapore and Abu Dhabi suggest that with appropriate and well-rehearsed ED workflows, a strategy of primary PCI can still be pursued for STEMI care, with little effect on overall DTB time. This is especially important in a prolonged pandemic response, given the superior outcomes of a primary PCI strategy.¹³

Nevertheless, despite the increase in DTB time, we did not find a corresponding significant increase in STEMI in-hospital mortality. Similarly, case fatality rates for NSTEMI, PCI and primary PCI remained largely constant. This is in keeping with reports from other studies, and is testament to the robustness of these medical systems in maintaining a high level of cardiovascular care despite the pandemic.^{16,14}

Data on PCI volumes provide some insights into how COVID-19 has affected elective procedures. The decrease in PCI in the present study was driven largely by data from Singapore, where there was an active push to reschedule non-urgent elective cardiac catheterisation. The decline in PCI in Singapore started with the onset of the COVID-19

pandemic and reached a nadir during the government-imposed ‘circuit breaker’ (7 April–1 June 2020). The fall can be explained by guidance from the Ministry of Health in Singapore and individual institutions to postpone non-urgent cases to free up bed space in anticipation of a surge in COVID-19-related admissions. Recovery ensued as healthcare systems adapted.

Limitations

Although this study sheds light on the effect of COVID-19 on cardiovascular care in Singapore, Malaysia and Abu Dhabi, the insights are largely limited to these countries and constrained by the particular circumstances of each country’s response to COVID-19. In addition, the data from Singapore and Abu Dhabi are from a single centre and may not be fully generalisable. As we highlighted earlier, reports on the effects of COVID-19 are context dependent and can differ greatly. Furthermore, our study concluded in December 2020, when case numbers in Malaysia and Abu Dhabi were still increasing. Further research into the effects of these second waves will be very instructive in ascertaining how healthcare systems deal with far higher COVID-19 case numbers despite being armed with protocols and experience in operating under pandemic conditions.

Conclusion

This study has shown that the COVID-19 pandemic has led to a fall in NSTEMI, but not STEMI, admissions. A reduction in the proportion of STEMI patients achieving a DTB time of ≤90 minutes may be related to the thrombolysis-first approach pursued by Malaysia. PCI volumes decreased, primarily driven by the deferral of non-urgent procedures in Singapore. There was no significant effect of the COVID-19 pandemic on in-hospital mortality. □

Clinical Perspective

- The COVID-19 pandemic resulted in a fall in non-ST segment elevation MI but not ST-elevation MI (STEMI) admissions in Singapore and Malaysia. This decrease appears to be related more to the implementation of nationwide lockdown measures rather than absolute COVID-19 case numbers.
- A reduction in the proportion of STEMI patients achieving a door-to-balloon time of ≤90 min may be related to the thrombolysis-first approach pursued by Malaysia.
- PCI volumes decreased due to deferral of non-urgent procedures, especially in Singapore.
- There was no significant effect of the COVID-19 pandemic on case fatalities from acute MI admissions or percutaneous coronary intervention procedures.

Table 4: Comparison of Case Fatality Rates for Percutaneous Coronary Intervention, Primary PCI, ST-Elevation MI and Non-ST-Elevation MI Admissions Before and During the COVID-19 Pandemic

	Before COVID-19		During COVID-19		RR (95% CI)	p-value (χ^2)
	Total No. Cases	Mortality, n (%)	Total No. Cases	Mortality, n (%)		
Overall						
Procedural						
PCI cases	13,089	203 (1.55)	11,449	165 (1.44)	0.9 (0.8–1.1)	0.480
Primary PCI	1,247	91 (7.30)	747	60 (8.03)	1.1 (0.8–1.5)	0.548
Admissions						
STEMI	1,420	78 (5.49)	1,233	57 (4.62)	0.8 (0.6–1.2)	0.309
NSTEMI	1,883	57 (3.03)	1,514	52 (3.43)	1.1 (0.8–1.6)	0.503
Singapore						
Procedural						
PCI cases	2,902	69 (2.38)	2,107	54 (2.56)	1.1 (0.8–1.5)	0.676
Primary PCI	493	45 (9.13)	350	42 (12.00)	1.3 (0.9–2.0)	0.177
Admissions						
STEMI	408	32 (7.84)	340	28 (8.24)	1.1 (0.6–1.7)	0.844
NSTEMI	814	34 (4.18)	722	35 (4.85)	1.2 (0.7–1.8)	0.527
Malaysia						
Procedural						
PCI cases	9,928	126 (1.27)	9,070	103 (1.14)	0.9 (0.7–1.2)	0.400
Primary PCI	719	45 (6.26)	341	16 (4.69)	0.7 (0.4–1.3)	0.306
Admissions						
STEMI	985	43 (4.37)	853	28 (3.28)	0.8 (0.5–1.2)	0.230
NSTEMI	925	20 (2.16)	604	14 (2.32)	1.1 (0.5–2.1)	0.840
Abu Dhabi						
Procedural						
PCI cases	259	8 (3.09)	272	8 (2.94)	1.0 (0.4–2.5)	0.921
Primary PCI	35	1 (2.86)	56	2 (3.57)	1.3 (0.1–13.3)	0.853
Admissions						
STEMI	27	3 (11.1)	40	1 (2.50)	0.2 (0.0–2.1)	0.145
NSTEMI	144	3 (2.08)	188	3 (1.60)	0.8 (0.2–3.7)	0.741

NSTEMI = non-ST segment elevation MI; STEMI = ST-elevation MI.

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