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Clinical Research

Care and Outcomes of ST-Segment Elevation Myocardial Infarction Across Multiple COVID-19 Waves

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See editorial by Verreault-Julien and Rinfret, pages 723–725 of this issue.

ABSTRACT

Background: There are concerns of delays in ST-segment elevation myocardial infarction (STEMI) care during the COVID-19 pandemic. It is unclear whether the care and outcomes of STEMI patients differ between COVID-19 waves and compared with historical periods.

Methods: Consecutive patients in the Vancouver Coastal Health Authority STEMI database were included to compare care during 3 distinct waves of the COVID-19 pandemic (9 months; March 2020 to January 2021) with an historical non–COVID-19 cohort. We compared STEMI incidence, baseline characteristics, and outcomes between

RÉSUMÉ

Contexte : On s'inquiète des retards dans la prise en charge des infarctus du myocarde avec élévation du segment ST (STEMI) pendant la pandémie COVID-19. Il n'est pas clair si les soins et les pronostics des patients STEMI diffèrent entre les vagues COVID-19 et par rapport aux périodes antérieures.

Méthodes : Des patients consécutifs issus de la base de données STEMI de la Vancouver Coastal Health Authority ont été inclus pour comparer les soins apportés au cours de trois vagues distinctes de la pandémie COVID-19 (neuf mois; de mars 2020 à janvier 2021) avec

Timely pharmacologic or mechanical reperfusion of the infarct-related artery remains the cornerstone of treatment for ST-segment elevation myocardial infarction (STEMI)[1]; delayed reperfusion is associated with increased morbidity and mortality.[2] The response to COVID-19 has placed considerable strain on health care systems, in terms of both physician resources and access to specialised care, and in this manner has affected the timely treatment of non–COVID-19 conditions such as STEMI.[3]

Significant regional variability also exists on the impact of the COVID-19 response on the management of STEMI patients. While patients in COVID-19 epicentres may be more reluctant to present to the hospital, resulting in potential delays in seeking acute cardiac care, this may not be the case in other regions less affected by COVID-19. For example, data emerging from mainland China, Northern Italy, and Spain revealed a significant delay in seeking first medical contact after symptom onset.[4-7] This, however, was not the case in less affected regions such as Germany or Belgium.[8,9] Similar regional variability of in-hospital mortality was found in a recent systematic review looking at STEMI outcomes during the COVID-19 pandemic.[10]

Despite these regional differences, consistent and significant delay in door-to-device times were seen during the COVID-19 pandemic.[10] These delays have been thought to be related to the need for stringent infection control measures adopted by local hospitals and extensive testing and preparation measures required for STEMI patients with suspected COVID-19 infection. However, no study to date has reported how outcomes in STEMI have differed over the multiple waves of infections with COVID-19.

The present analysis aimed to evaluate the regional impact of the COVID-19 outbreak on STEMI care and patient outcomes in the Vancouver Coastal Health Authority (VCHA) during multiple COVID-19 waves with 4 specific objectives. The first objective was to compare the incidence of

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groups. We also examined time from first medical contact (FMC) to reperfusion, symptom to FMC, and FMC to STEMI diagnosis, as well as predictors of delays.

Results: The incidence of STEMI was similar during COVID-19 (n = 305; mean 0.93/day) and before COVID-19 (n = 949; 0.97/day; $P = 0.80$). The COVID-19 cohort showed significant delay in FMC-to-reperfusion (median 116 min vs 102 min; $P < 0.001$) and FMC-to-STEMI diagnosis (median 17 mins vs 11 min; $P < 0.001$). Delays in FMC-to-device times worsened across the 3 COVID-19 waves (FMC-to-device time $\leq$ 90 min in wave 1: 32.9%; in wave 2: 25.6%; in wave 3: 16.3%; $P = 0.045$ [47.5% before COVID-19; $P < 0.001$]). There were no significant predictors of delay were unique to the COVID-19 cohort.

Conclusions: This study demonstrates delays in reperfusion during the COVID-19 pandemic compared with the historical control, with delays increasing during subsequent waves within the pandemic. It is critical to further understand these care gaps to improve STEMI care for future waves of the current and future pandemics.

ceux d'une cohorte historique non-COVID-19. Nous avons comparé l'incidence des STEMI, les caractéristiques de base et les pronostics entre les groupes. Nous avons également examiné le délai entre le premier contact médical (PCM) et la reperfusion, entre l'apparition de symptôme et le PCM, et entre le PCM et le diagnostic de STEMI, ainsi que les prédicteurs des délais.

Résultats : L'incidence du STEMI était similaire pendant la COVID-19 (n = 305; moyenne de 0,93/jour) et avant COVID-19 (n = 949; 0,97/jour; $P = 0,80$). La cohorte COVID-19 a montré un retard significatif entre le PCM et la reperfusion (médiane 116 min vs 102 min; $P < 0,001$), et entre le PCM et le diagnostic de STEMI (médiane 17 min vs 11 min; $P < 0,001$). Les retards dans les délais entre le PCM et l'installation du dispositif se sont aggravés au cours des trois vagues de COVID-19 (délai PCM-dispositif $\leq$ 90 min durant la vague 1 : 32,9 % ; durant la vague 2 : 25,6 % ; durant la vague 3 : 16,3 % ; $P = 0,045$ [47,5 % avant COVID-19; $P < 0,001$]). Aucun prédicteur de retard significatif n'était propre à la cohorte COVID-19.

Conclusions : Cette étude met en lumière des retards dans la reperfusion pendant la pandémie COVID-19 par rapport à la période historique servant de contrôle, les retards augmentant pendant les vagues successives de la pandémie. Il est essentiel de mieux comprendre ces lacunes en matière de soins afin d'améliorer les soins STEMI pour les vagues futures des pandémies actuelles et futures.

STEMI cases during the COVID-19 outbreak with the incidence before the pandemic, as well as to assess trends in the incidence of STEMI cases among 3 distinct waves of the pandemic. The second objective was to determine the difference in baseline clinical characteristics between patients presenting with STEMI during the COVID-19 outbreak compared with before the pandemic. The third objective was to compare care and outcomes of STEMI patients during and before the COVID-19 pandemic as exploratory outcomes, as well as during the 3 waves of the pandemic. And the fourth objective was to determine predictors of delay in care in STEMI patients presenting during the COVID-19 pandemic and in the pre-pandemic period.

Materials and Methods

Study participants

In this study, we included all patients with STEMI referred to the VCHA during the COVID-19 outbreak for a period from March 11, 2020, to January 31, 2021. This included all patients who were medically managed or who underwent reperfusion with fibrinolysis or primary percutaneous coronary intervention (pPCI), which is defined as a strategy of taking patients with STEMI directly for PCI. Patients with STEMI complicated with out-of-hospital cardiac arrest were also included. To serve as an historical comparator group, all patients with STEMI in the VCHA regional STEMI registry from March 11 to January 31 in 2017, 2018, and 2019 were included as control subjects.

Data collected

All data were collected and analysed at the Centre for Health Evaluation and Outcomes Sciences. In existence since 2007, the VCHA STEMI database (n = 4400 patients) provides continuous and ongoing collection of detailed pre- and in-hospital information on consecutive STEMI patients presenting to VCHA hospitals (12 hospitals serving 25% of the British Columbia population, both urban and rural) for stakeholder reporting and quality improvement, as previously described.[11-13]

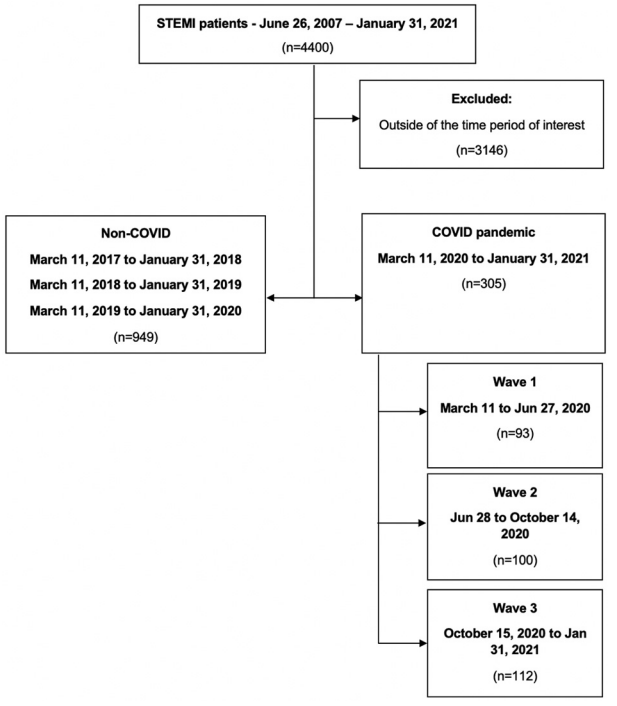

Figure 1. Cohort derivation. STEMI, ST-segment elevation myocardial infarction.

Table 1. Baseline demographics and presentation characteristics

Variable	Pre–COVID-19	COVID-19	Difference (95% CI)	*P* value
Baseline demographics				
Total, n	949	305		
Age, years	65.6	65.4	−0.2 (−1.8 to 1.4)	0.85
Weight, kg	79.9	80.3	0.4 (−1.9 to 2.7)	0.71
BMI, kg/m^2	27.0	27.2	0.2 (−0.7 to 1.1)	0.62
Male sex	771 (81.2)	215 (75.7)	−5.5 (−11.2 to −0.1)	0.04*
Current/recent smoker	230 (24.5)	78 (29.0)	4.5 (−1.4 to 10.7)	0.13
Hypertension	557 (59.1)	149 (54.0)	−5.1 (−11.7 to 1.6)	0.13
Dyslipidemia	418 (44.4)	125 (45.3)	0.9 (−5.7 to 7.6)	0.78
Diabetes	229 (24.3)	69 (25.1)	0.8 (−4.9 to 6.7)	0.79
Chronic kidney disease	261 (28.1)	86 (31.3)	3.2 (−2.9 to 9.4)	0.23
Dialysis	6 (0.6)	5 (1.8)	1.2 (−0.4 to 3.2)	0.07
Previous MI	124 (13.2)	27 (10.0)	−3.2 (−7.2 to 1.3)	0.17
Previous HF	33 (3.5)	6 (2.2)	−1.3 (−3.3 to 1.2)	0.29
Previous AF	77 (8.2)	23 (8.4)	0.2 (−3.4 to 4.1)	0.92
Previous PCI	98 (10.4)	25 (9.1)	−1.4 (−5.1 to 2.8)	0.51
Previous CABG	23 (2.4)	3 (1.1)	−1.4 (−2.8 to 0.6)	0.17
Previous PVD	31 (3.3)	8 (2.9)	−0.4 (−2.5 to 2.2)	0.75
Presentation characteristics				
Initial HR, beats/min	76 (63 to 92)	75 (60 to 88)	−1 (−5 to 3)	0.33
Initial SBP, mm Hg	140 (118 to 162)	142 (118 to 163)	2 (−4 to 8)	0.79
Initial creatinine, mmol/L	94 (79 to 110)	96 (81 to 115)	2 (−2 to 6)	0.19
New-onset AF	56 (6.0)	19 (6.9)	1.0 (−2.2 to 4.6)	0.56
Anterior MI	460 (48.5)	148 (48.7)	0.2 (−6.2 to 6.7)	0.95
HF on presentation	50 (5.3)	33 (12.2)	6.9 (2.9 to 11.3)	< 0.001*
Cardiogenic shock on presentation	93 (9.9)	25 (9.2)	−0.7 (−4.5 to 3.4)	0.71
Pre-hospital cardiac arrest	96 (10.2)	28 (10.2)	0.0 (−3.9 to 4.3)	0.99
Presentation to PCI-capable centre	620 (65.4)	199 (65.2)	−0.1 (−6.3 to 6.0)	0.98
Fibrinolytic	40 (4.2)	4 (1.3)	−2.9 (−4.6 to −0.8)	0.02*
Primary PCI	796 (83.9)	267 (87.8)	4.0 (−0.6 to 8.1)	0.095
Referred for CABG	77 (8.1)	30 (9.9)	1.8 (−1.9 to 5.7)	0.34

Values are mean, n (%), or median (interquartile range).

AF, atrial fibrillation; BMI, body mass index; CABG, coronary artery bypass grafting; HF, heart failure; HR, heart rate; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; SBP, systolic blood pressure.

* $P < 0.05$.

For the present study, STEMI patients were stratified into whether they presented during the COVID-19 pandemic (March 11, 2020, to January 31, 2021) vs during a non–COVID-19 time period (March 11 to January 31, 2017, 2018, and 2019) (Fig. 1). For secondary analyses, patients presenting during the COVID-19 pandemic were sub-classified into 3 distinct waves corresponding with 3 consecutive 109-day intervals: wave 1, March 11 to June 27, 2020; wave 2, June 28 to October 14, 2020; and wave 3, October 15, 2020 to January 31, 2021. All data were collected by the VCHA STEMI database study coordinators by means of retrospective chart review with the use of a standard data collection form.

Outcomes and definitions

The co-primary outcomes were STEMI incidence and time from first medical contact (FMC) to reperfusion during

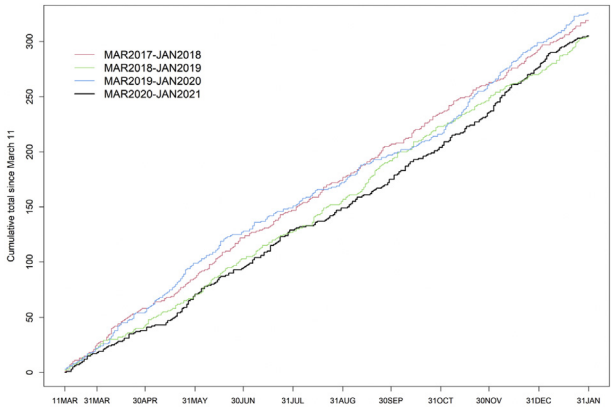

Figure 2. Cumulative number of ST-segment elevation myocardial infarction (STEMI) cases from March 11 of each time period.

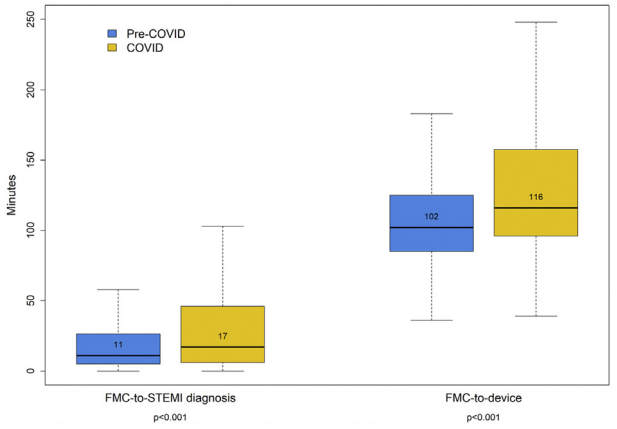

Figure 3. FMC-to-STEMI diagnosis and FMC-to-device intervals in the pre–COVID-19 and COVID-19 cohorts. FMC, first medical contact; STEMI, ST-segment elevation myocardial infarction.

Table 2. Time point interval outcomes

Variable	Pre–COVID-19 (n = 949)	COVID-19 (n = 305)	Difference (95% CI)	*P* value
All patients				
Symptom onset to FMC, min*	63 (28 to 170)	64 (28 to 180)	1 (−14 to 16)	0.685
FMC to STEMI diagnosis, min†	11 (5 to 27)	17 (6 to 46)	6 (3 to 9)	< 0.001
Primary PCI				
FMC-to-device‡,§				< 0.001
≤ 90 (or 120) min	356 (47.5)	59 (24.3)	−23.2 (16.5 to 29.4)	
> 90 (or 120) min	394 (52.5)	184 (75.7)		
FMC-to-device, min‡				
All patients	102 (85 to 125)	116 (96 to 158)	14 (8 to 20)	< 0.001
Direct	95 (78 to 117)	106 (91 to 131)	11 (5 to 17)	< 0.001
Transfer	117 (103 to 142)	145 (112 to 220)	28 (16 to 38)	< 0.001
Thrombolysis				
FMC-to-lytic				0.539
≤ 30 min	14 (35.0)	0 (0.0)	−35.0 (−53.7 to 22.2)	
> 30 min	26 (65.0)	3 (100)		
FMC-to-lytic, min	40 (26 to 50)	37 (34 to 55)	−3 (−33 to 27)	0.812

Values are median (interquartile range) or n (%).

CI, confidence interval; FMC, first medical contact; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

* Data unknown in 5 pre-COVID-19 patients and 10 COVID-19 patients.

† Data unknown in 2 pre-COVID-19 and 5 COVID-19 patients.

‡ Data unknown in 4 pre-COVID-19 and 2 COVID-19 patients.

§ ≤ 90 minutes in primary PCI centres, ≤ 120 minutes in non-PCI centres.

COVID-19 compared with before COVID-19. Our secondary outcomes included times from symptom to FMC and from FMC to STEMI diagnosis. We examined in-hospital clinical outcomes as exploratory analyses. These included all-cause mortality, major bleeding events, congestive heart failure, cardiogenic shock, in-hospital cardiac arrest, left ventricular ejection fraction after STEMI, and length of hospital stay.

Finally, we identified predictors for timely pPCI (FMC-to-device ≤ 90 min for direct presenters, ≤ 120 min for transfers) in patients presenting with STEMI during and before the COVID-19 pandemic.

Statistical analyses

All data were analysed with Statistical Analysis System (SAS) software version 9.2 (SAS Institute, Cary, NC). Continuous variables were measured as median with interquartile range (IQR) or mean ± SD, and categoric variables were measured as percentage. Comparisons between the COVID-19 and pre–COVID-19 cohorts were performed by means of the Kruskal-Wallis test or analysis of variance (ANOVA) for continuous variables and the χ^2 or Fisher exact test for categoric variables as appropriate. STEMI-related time intervals were compared among the 3 waves in the same fashion. We further used quantile regression with natural cubic spline to examine how the median of the STEMI-related time intervals changed during the COVID-19 period. To avoid overfitting the data, the number of knots for the cubic spline was chosen based on goodness of fit of the model as assessed with the use of the Akaike information criterion; a maximum of 5 knots was used owing to limited sample size. Proportion of patients with delayed pPCI during the COVID-19 period was similarly analysed with the use of spline logistic regression. Univariate logistic regression analyses were done to determine the associations of clinically important patient- and system-level variables with FMC-to-device time ≤ 90 min (or ≤ 120 min for transfers) in the COVID-19 and pre–COVID-19 cohorts. Variables with $P <$ 0.1 in the univariate analysis were included in a multivariable logistic regression model for further assessment. Statistical significance was determined as a P value of < 0.05.

The authors had full access to and take full responsibility for the integrity of the data. All of the authors read and agreed to the manuscript as written. This project was conducted in compliance with the protocol and principles laid down in the Declaration of Helsinki, along with other local regulatory requirements. Before the study initiation, written approval from the University of British Columbia Ethics Review Board was obtained (H05-50241).

Results

There were 1254 patients who met the inclusion criteria, including 305 (25.4%) during the COVID-19 pandemic and 949 during the same time periods from 2017 to 2019. Most participants were male (80%), and the overall mean age was 65.6 years (Fig. 1). The COVID-19 and pre–COVID-19 groups were similar in baseline cardiac risk factors, medical comorbidities, and previous revascularisation (Table 1). Sixty-five percent of patients in both cohorts presented to PCI-capable centres. There was no statistical difference in STEMI incidence during COVID-19 (0.93/day) compared with before COVID-19 (0.97/day; $P = 0.80$) (Fig. 2) (Supplemental Table S1). There was no difference in initial heart rate (77 vs 75 beats/min, 95% CI −5 to 3; $P = 0.33$) and systolic blood pressure (142 vs 140 mm Hg, 95% CI −4 to 8; $P = 0.79$) in the COVID-19 vs pre–COVID-19 cohorts, respectively. Similarly, there was no significant difference in pre-hospital cardiac arrest or cardiogenic shock on presentation (9.2% vs 9.9%, 95% CI −4.5 to 3.4; $P = 0.71$). There was a significantly higher incidence of heart failure on presentation in the COVID-19 group compared with the pre–COVID-19 group (12.2% vs 5.3%, 95% CI 2.9 to 11.3; $P < 0.001$).

There was no difference between groups from symptom onset to seeking medical attention, with a median symptom-

Table 3. Trends among the 3 waves* of the COVID-19 pandemic

Variable	COVID 1	COVID 2	COVID 3	*P* value
All patients, n	93	100	112	
Symptom onset to FMC, min				0.092
Median (IQR)	57 (23-135)	70 (27.5-207)	70 (33-245)	
Range	0-1405	2-5725	0-1512	
FMC to STEMI diagnosis, min				0.303
Median (IQR)	16 (6 to 40.5)	15.0 (5 to 43)	23.0 (7 to 55)	
Range	(0 to 268)	(0 to 1683)	(0 to 720)	
Primary PCI patients, n	73	78	92	
FMC-to-device, n (%)				0.045†
≤ 90 (or 120) min	24 (32.9)	20 (25.6)	15 (16.3)	
> 90 (or 120) min	49 (67.1)	58 (74.4)	77 (83.7)	
FMC-to-device, min				0.059
Median (IQR)	110 (91-142)	116 (92-152)	122 (100-169)	
Range	(66-362)	(39-1780)	(52-2258)	

FMC, first medical contact; IQR, interquartile range; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.
*COVID 1: March 11 to June 27, 2020 (109 days); COVID 2: June 28 to October 14, 2020 (109 days); COVID 3: October 15, 2020 to January 31, 2021 (109 days).
† $P < 0.05$.

to-FMC interval of 64 (IQR 28-180) minutes in the COVID-19 group compared with 63 (IQR 28-170) minutes in the pre−COVID-19 group ($P = 0.685$). There was a statistically significant delay in time from FMC to STEMI diagnosis in the COVID-19 group compared with the pre−COVID-19 group (median 17 min vs 11 min; $P < 0.001$) (Fig. 3). Ultimately, there was a significant delay in FMC-to-device time with primary PCI in the COVID-19 group compared with the pre−COVID-19 group (median 116 min vs 102 min; $P < 0.001$). This delay in FMC-to-reperfusion time was not seen in patients who had fibrinolytic therapy (Table 2).

FMC-to-device, symptom-to-FMC, and FMC-to-STEMI diagnosis times did not differ between COVID-19 waves (Table 3). However, the proportion of patients with FMC-to-device time ≤ 90 minutes (or ≤ 120 minutes when presenting at a non-PCI centre) decreased across subsequent waves (wave 1: 32.9%; wave 2: 25.6%; wave 3: 16.3%; $P = 0.045$). There was a similar trend seen in FMC-to-device time (wave 1: 110 (IQR 91.0-142) min, wave 2: 116 (IQR 92.0-152) min, wave 3: 122 (IQR 100-169) min; $P = 0.059$) (Fig. 4). When analysing the COVID-19 period in a continuous fashion during the study period, there was

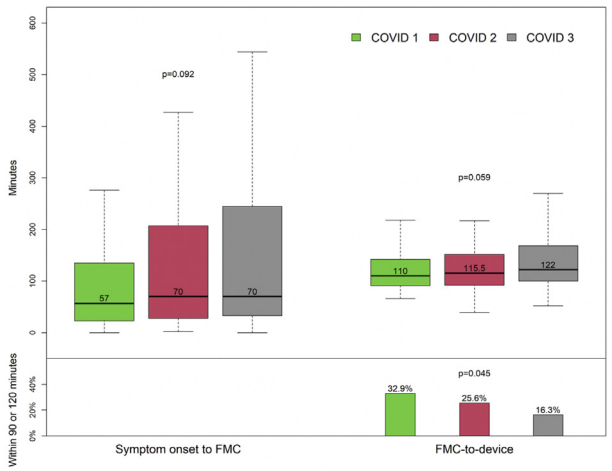

Figure 4. Symptom-to-FMC and FMC-to-device times in the 3 phases of COVID-19. FMC, first medical contact.

significant increase in FMC-to-device time ($P = 0.037$) as the pandemic progressed, with the highest delay being in the third COVID-19 wave (Fig. 5). This was also accompanied by a trend to increased FMC-to STEMI diagnosis interval in wave 3, although that did not reach statistical significance ($P = 0.053$). There was not a statistically significant change in symptom-to-FMC time.

Exploratory in-hospital clinical outcomes were analysed and are presented in Table 4. There was no difference in mortality from STEMI between the pre−COVID-19 and COVID-19 groups. Similarly, there was no difference in in-hospital cardiac arrest, reinfarction, developing cardiogenic shock, left ventricular ejection fraction, or length of hospital stay. Fewer patients experienced major bleeding events in the COVID-19 group (odds ratio [OR] 0.67, 95% CI 0.45-0.99; $P = 0.04$).

Finally, when examining predictors of delay in FMC-to-device time in the COVID-19 cohort, several predictors were found (Table 5); however, there were no significant differences between the COVID-19 and pre−COVID-19 cohorts in terms of the association between delay in FMC-to-device time and potential predictors (all $P > 0.05$ for homogeneity of OR) (Supplemental Table S2). Increasing age (OR 1.22 per 5 years, 95% CI 1.07-1.38; $P = 0.002$) was the only demographic variable that was found to be a significant predictor (Table 5). A cardiac arrest complicating STEMI on presentation strongly delayed FMC-to-device time (OR 17.86, 95% CI 1.00-318.76; $P = 0.05$). Similarly, STEMI presentation outside of daytime hours predicted delayed FMC-to-device time, with the strongest association seen with presentation between 00:00 to 07:59 (OR 2.52; 95% CI 1.14-5.57; $P = 0.023$). In particular, there were no unique predictors of delay in FMC-to-device time in the COVID-19 cohort that were not also present in the pre−COVID-19 cohort (Supplemental Table S3). Our findings remained the same in the multivariable analysis (Supplemental Table S4).

Discussion

In this study, there was a significant delay in STEMI care in patients presenting during the COVID-19 pandemic compared with the same time frames in the 3 years preceding

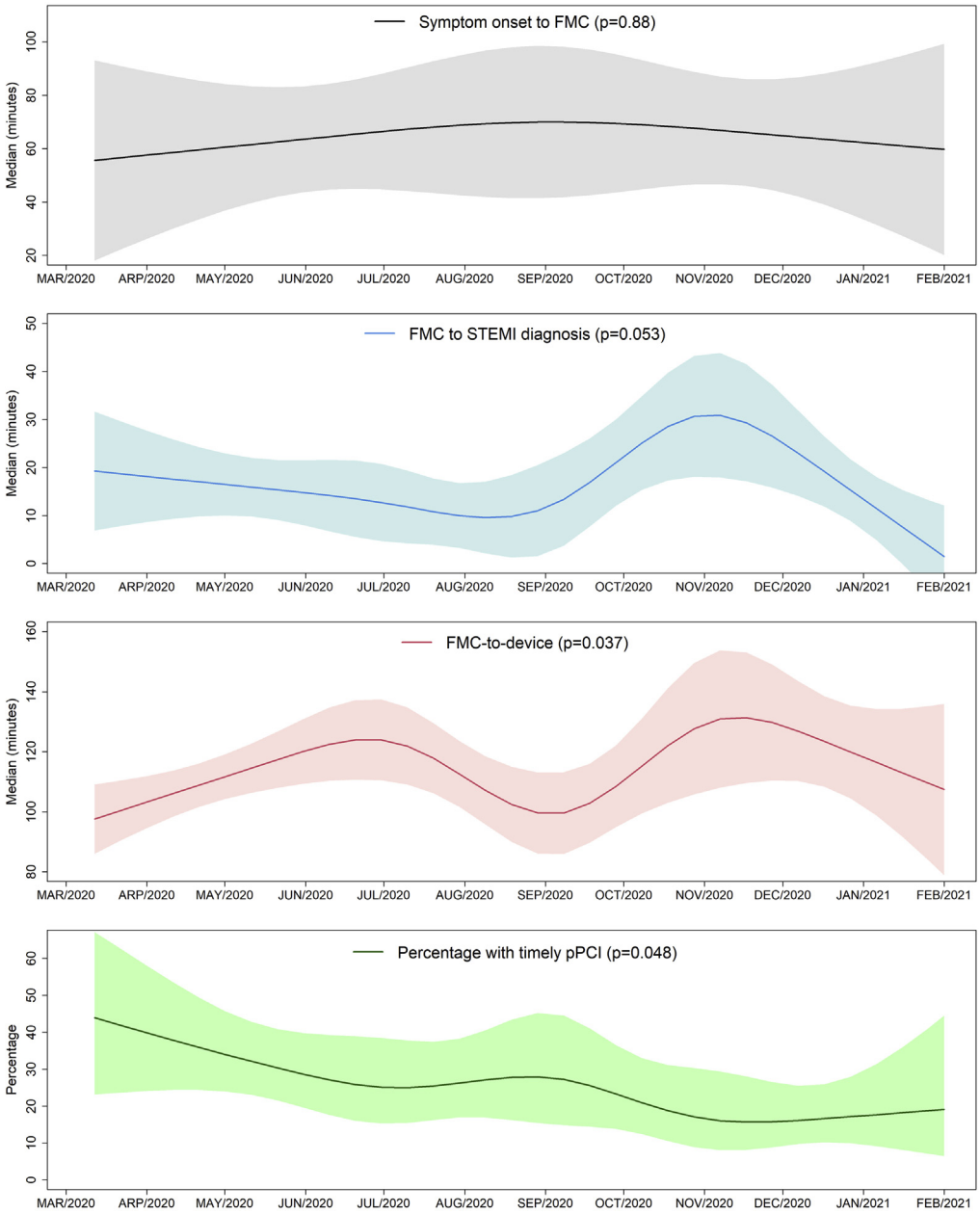

Figure 5. STEMI-related time intervals during the COVID-19 period with spline regression. FMC, first medical contact; pPCI, primary percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

COVID-19. Furthermore, there was a significant increase in time from FMC-to-STEMI diagnosis and FMC-to-reperfusion time. These findings point to delays in in-hospital processes, which is supported by a large systematic review and meta-analysis by Rattka et al.[10] Similar findings have been reported in observational studies around the world,[4,8,9,14-19] including a recently published Canadian study by Clifford et al., who described STEMI care in an Ontario population during the COVID-19 pandemic.[14]

Our results were discrepant with previously reported studies in that we did not find that there was a significant reduction in patients presenting with STEMI during the COVID-19 pandemic. Average STEMI numbers per day were 0.93 during the COVID-19 pandemic vs 0.97 in the historical control group ($P = 0.80$). Rattka et al.'s systematic review, for example, found that there was a 22% reduction in patients presenting with STEMI during the COVID-19 pandemic compared with before.[10] Similarly, there was a 16% reduction in coronary angiography for STEMI seen across Canada in a national study published by Rinfret et al. during a 3-month COVID-19 period compared with a historical control.[20] However, in that study, there was no statistical difference seen in British Columbia, which is concordant with our results.

The discrepancy between STEMI incidence between British Columbia and other provinces in Canada can

Table 4. In-hospital clinical outcomes (exploratory outcomes)

Outcomes	Pre−COVID-19 (n = 949)	COVID-19 (n = 305)	*P* value	OR (95% CI)
Death	74/948 (7.8)	15/276 (5.4)	0.182	0.68 (0.38-1.20)
In-hospital cardiac arrest	137/940 (14.6)	35/275 (12.7)	0.440	0.85 (0.57-1.27)
In-hospital cardiac arrest			0.008*	—
No	803 (85.4)	240 (87.3)		
Yes, after catheterisation	72 (7.7)	8 (2.9)		
Yes, before catheterisation	65 (6.9)	27 (9.8)		
Major bleeding	168/940 (17.9)	35/275 (12.7)	0.044*	0.67 (0.45-0.99)
Reinfarction	7/940 (0.7)	2/273 (0.7)	0.984	1.15 (0.27-4.84)
ICH/CVA/stroke	16/940 (1.7)	5/274 (1.8)	0.891	1.14 (0.43-3.03)
Cardiogenic shock	129/939 (13.7)	33/274 (12.0)	0.468	0.86 (0.57-1.29)
Heart failure	209/939 (22.3)	51/274 (18.6)	0.196	0.80 (0.57-1.12)
LVEF closest to discharge, %			0.968	—
Mean ± SD	46.9 ± 10.8	46.9 ± 10.3		
Median (IQR)	48.0 (40.0-55.0)	49.0 (40.0-55.0)		
Hospital length of stay, days†			0.880	—
Median (IQR)	3.0 (2.4-4.8)	3.0 (2.4-4.2)		
Range	(0.3-249.9)	(1.2-63.0)		

Values are n (%) unless otherwise specified.

CI, confidence interval; CVA, cerebrovascular accident; ICH, intracerebral hemorrhage; IQR, interquartile range; LVEF, left ventricular ejection fraction; OR, odds ratio.

* $P < 0.05$.

† Among those who were discharged alive.

perhaps be explained by lower rates of COVID-19 cases in British Columbia compared with other areas around the world during this timeframe. According to statistics provided by the British Columbia Centre for Disease Control (BCCDC), COVID-19 cases were relatively low (consistently less than 200 cases per day) for the first several months of the pandemic, before surging to 800 cases per day in November and December 2020.[21] As British Columbia had a relatively delayed "spike" in COVID-19 numbers, it is possible that patients did not have as much perceived fear of presenting to hospital as patients in other countries and regions that were heavily affected earlier on during the pandemic.[21-23] This may also represent a concerted effort by public health officials and physicians in British Columbia in raising education around cardiovascular disease and the importance of seeking help despite concerns over the pandemic. This lack of fear of presenting to health care during the COVID-19 pandemic is further supported by our finding of no difference in symptom-to-FMC interval between the COVID-19 and pre−COVID-19 cohorts.

As far as we are aware, we are the first to report "inter-wave" data on STEMI care during the COVID-19 pandemic. To evaluate STEMI care within the different waves of the pandemic, we divided the COVID-19 pandemic into 3 consecutive 109-day intervals. Surprisingly, we found that as the COVID-19 pandemic progressed, there was a statistically significant increased number of patients that did not meet the goal FMC-to-device time. There was also a trend toward longer symptom-to-FMC and FMC-to-STEMI diagnosis times.

These findings could be explained by increased COVID-19 cases in British Columbia, including hospitalisations, within wave 3 compared with the earlier waves.[21] Strict precautions to increase available health care resources and personnel were taken during wave 1, which were liberalised as the pandemic progressed.[24] These measures included reducing the number of elective cardiac and noncardiac procedures to make facilities as well as health care personnel more available for the anticipated surge of COVID-19 cases. Because there were fewer cases than expected in wave 1, and more than expected as the pandemic progressed when concurrently these precautions were liberalised, this led to a relative mismatch in available resources and COVID-19 case surges. This increased stress on in-hospital systems from the surge in the COVID-19 pandemic, including the emergency department, may explain the delays in STEMI care including timely reperfusion.

We examined predictors of delayed FMC-to-device time. Consistent with previous pre−COVID-19 observations from our group,[25] we found that increasing age, cardiac arrest on presentation, and presenting outside of daytime hours were associated with delays to reperfusion, and we did not identify any predictors of delays to reperfusion unique to the COVID-19 era.

Finally, within our exploratory in-hospital outcomes, we did not find a significant difference in hard clinical outcomes such as cardiac arrest, reinfarction, cardiogenic shock, or left ventricular function. Similarly, there was no difference in overall mortality or hospital length of stay. This trend of no difference in mortality despite increase in door-to-balloon time was also seen in previous observational studies.[10,14] Although timely revascularisation has been a longstanding cornerstone of care for STEMI, an observational study by Menees et al. showed that a 16-minute reduction (from 83 to 67 minutes) in door-to-balloon time did not result in a difference in in-hospital mortality.[26] This suggests that in a contemporary STEMI population, consideration of other aspects of care, such as guideline-recommended medical therapy, consideration of complete revascularisation and treating comorbid conditions to stabilise the patient before revascularisation, may be more relevant than focusing on door-to-balloon time alone.

Study limitations

These data were collected from a single health authority. Although there are multiple referring centres within that

Table 5. Univariate association of covariates with delayed FMC-to-device time in the pre–COVID-19 and COVID-19 cohorts

Variable	Pre–COVID-19		COVID-19		
	OR (95% CI)*	*P* value	OR (95% CI)*	*P* value	*P* for homogeneity†
Age, per 5-year increase	1.15 (1.08-1.22)	< 0.001‡	1.22 (1.07-1.38)	0.002‡	0.445
Weight, per 5-kg increase	0.95 (0.91-0.99)	0.015‡	0.95 (0.87-1.03)	0.237	0.941
BMI, per 5-unit increase	0.86 (0.75-1.00)	0.043‡	0.91 (0.68-1.22)	0.538	0.726
Male sex	0.55 (0.37-0.82)	0.003‡	0.51 (0.24-1.07)	0.076	0.864
Current/recent smoker	0.73 (0.52-1.03)	0.076	1.25 (0.63-2.48)	0.526	0.174
Dyslipidemia	1.32 (0.99-1.77)	0.058	0.83 (0.46-1.50)	0.536	0.165
Hypertension	1.46 (1.09-1.95)	0.011‡	1.79 (0.98-3.26)	0.057	0.547
Currently on dialysis	1.28 (0.21-7.60)	0.788	0.80 (0.09-6.93)	0.839	0.743
Diabetes	1.04 (0.74-1.46)	0.803	0.88 (0.45-1.72)	0.705	0.653
Previous MI	1.60 (1.03-2.49)	0.036‡	0.89 (0.33-2.38)	0.818	0.285
Previous atrial fibrillation	1.39 (0.77-2.53)	0.277	1.44 (0.42-4.99)	0.563	0.960
Previous heart failure	1.41 (0.60-3.29)	0.428	0.63 (0.12-3.44)	0.594	0.406
Prior PCI	1.14 (0.71-1.83)	0.598	1.38 (0.46-4.17)	0.567	0.751
Previous CABG	1.28 (0.48-3.40)	0.617	2.44 (0.08-75.70)	0.610	0.723
Previous PVD	1.30 (0.55-3.09)	0.545	0.62 (0.11-3.36)	0.575	0.439
Initial HR, per 5 beats/min increase	1.00 (0.96-1.03)	0.861	0.98 (0.93-1.04)	0.568	0.676
Initial SBP, per 5 mm Hg increase	0.97 (0.95-0.99)	0.004‡	0.99 (0.95-1.03)	0.511	0.472
Initial creatinine, per 5 mmol/L increase	1.04 (1.01-1.06)	0.003‡	1.04 (0.99-1.08)	0.117	0.945
Heart failure on presentation	4.07 (1.57-10.60)	0.004‡	1.12 (0.43-2.90)	0.821	0.060
Cardiogenic shock on arrival	3.58 (1.91-6.70)	< 0.001‡	16.27 (0.90-292.98)	0.059	0.316
Pre-hospital cardiac arrest	2.04 (1.22-3.43)	0.007‡	17.86 (1.00-318.76)	0.050‡	0.147
New-onset atrial fibrillation	1.36 (0.68-2.71)	0.389	1.02 (0.28-3.71)	0.978	0.703
Infract type anterior	1.12 (0.84-1.49)	0.442	0.79 (0.44-1.43)	0.438	0.301
Weekend (Fri 17h00–Mon 7h59)	2.43 (1.79-3.31)	< 0.001‡	1.31 (0.70-2.43)	0.395	0.078
Time of day					0.832
Daytime (08h00-16h59)	1		1		
Evening (17h00-23h59)	1.66 (1.17-2.35)	0.004‡	2.12 (1.00-4.48)	0.049‡	
Night (00h00-07h59)	2.18 (1.49-3.18)	< 0.001‡	2.52 (1.14-5.57)	0.023‡	
ED arrival time					0.077
Weekday daytime	1		1		
Weekday evening	2.33 (1.45-3.74)	< 0.001‡	1.88 (0.71-5.01)	0.206	
Weekday night	3.61 (2.21-5.88)	< 0.001‡	2.40 (0.86-6.71)	0.096	
Weekend daytime	4.93 (3.08-7.90)	< 0.001‡	1.03 (0.43-2.44)	0.950	
Weekend evening	3.01 (1.87-4.87)	< 0.001‡	2.31 (0.82-6.49)	0.112	
Weekend night	3.27 (1.87-5.73)	< 0.001‡	2.51 (0.82-7.66)	0.107	

BMI, body mass index; CABG, coronary artery bypass grafting; CI, confidence interval; ED, emergency department; FMC, first medical contact; HR, heart rate; MI, myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; SBP, systolic blood pressure.

*OR > 1 implied more likelihood to have FMC–to-device time > 90/120 minutes.

†*P* for homogeneity assessed if the OR of delay for the specific variable before COVID-19 was the same as the OR during COVID-19.

‡$P < 0.05$.

health authority, our results are reflective of a single STEMI program and its inherent strengths and weaknesses. Similarly, despite our relatively large Canadian cohort, it is possible that we were underpowered to show statistically significant difference in clinical outcomes. Our results, however, are largely consistent with previously reported observational data from Canada as well as internationally, which suggests that our findings are largely generalisable. Furthermore, there were some missing data in our patient cohort, largely coming from the latest months of the COVID-19 pandemic. Overall, 3.9% of patients did not have complete demographic and clinical data regarding their STEMI presentation. However, regarding the primary and secondary outcomes of interest, only 1.2% of patients did not have full data collected. As such, missing data were unlikely to affect the present findings.

Conclusion

The present study found delays in reperfusion during the COVID-19 pandemic compared with an historical control. Furthermore, delays in FMC-to-device time worsened over subsequent COVID-19 waves, coinciding with increased COVID-19 case burden in British Columbia. It is critical to further understand and adapt policy to address these care gaps during increased surges of COVID-19 cases to improve current gaps in STEMI care during these times.

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Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Cardiology* at www.onlinecjc.ca and at https://doi.org/10.1016/j.cjca.2022.01.033.