

Original Article

The COVID-19 Pandemic and Coronary Angiography for ST-Elevation Myocardial Infarction, Use of Mechanical Support, and Mechanical Complications in Canada: A Canadian Association of Interventional Cardiology National Survey

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Ethics Statement: Due to the nature of the data collected (anonymized administrative data, and shared by centres), this study received a waiver for formal research ethics board review at McGill University Health Centre.

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ABSTRACT

Background: As a result of the COVID-19 pandemic first wave, reductions in ST-elevation myocardial infarction (STEMI) invasive care, ranging from 23% to 76%, have been reported from various countries. Whether this change had any impact on coronary angiography (CA) volume or on mechanical support device use for STEMI and post-STEMI mechanical complications in Canada is unknown.

Methods: We administered a Canada-wide survey to all cardiac catheterization laboratory directors, seeking the volume of CA use for STEMI performed during the period from March 1 2020 to May 31, 2020 (pandemic period), and during 2 control periods (March 1, 2019 to May 31, 2019 and March 1, 2018 to May 31, 2018). The number of left ventricular support devices used, as well as the number of ventricular septal defects and papillary muscle rupture cases diagnosed, was also recorded. We also assessed whether the number of COVID-19 cases recorded in each province was associated with STEMI-related CA volume.

Results: A total of 41 of 42 Canadian catheterization laboratories (98%) provided data. There was a modest but statistically significant 16% reduction (incidence rate ratio [IRR] 0.84; 95% confidence interval 0.80-0.87) in CA for STEMI during the first wave of the pandemic, compared to control periods. IRR was not associated with provincial COVID-19 caseload. We observed a 26% reduction (IRR 0.74; 95% confidence interval 0.61-0.89) in the use of intra-aortic balloon pump use for STEMI. Use of an Impella pump and mechanical complications from STEMI were exceedingly rare.

Conclusions: We observed a modest 16% decrease in use of CA for STEMI during the pandemic first wave in Canada, lower than the level reported in other countries. Provincial COVID-19 caseload did not influence this reduction.

RÉSUMÉ

Introduction : Après la première vague de la pandémie de COVID-19, de nombreux pays ont déclaré une réduction de 23 % à 76 % des soins invasifs de l'infarctus du myocarde avec élévation du segment ST (STEMI). On ignore si ce changement a entraîné des répercussions sur le volume d'angiographies coronariennes (AC) ou sur l'utilisation des dispositifs d'assistance mécanique lors de STEMI et des complications mécaniques post-STEMI au Canada.

Méthodes : Nous avons réalisé un sondage pancanadien auprès de tous les directeurs de laboratoire de cathétérisme cardiaque pour obtenir le volume d'utilisation des AC lors des STEMI réalisées durant la période du 1^{er} mars 2020 au 31 mai 2020 (période de pandémie) et durant 2 périodes témoins (1^{er} mars 2019 au 31 mai 2019 et 1^{er} mars 2018 au 31 mai 2018). Le nombre de dispositifs d'assistance ventriculaire gauche utilisés et le nombre de cas de communications interventriculaires et de ruptures du muscle papillaire diagnostiqués ont également été enregistrés. Nous avons aussi évalué si le nombre de cas de COVID-19 enregistrés dans chaque province était associé au volume d'AC liées aux STEMI.

Résultats : Au total, 41 des 42 laboratoires canadiens de cathétérisme (98 %) ont fourni des données. Lors de la comparaison de la première vague de la pandémie aux périodes témoins, nous avons noté une réduction modeste, mais significative, sur le plan statistique de 16 % (ratio du taux d'incidence [RTI] 0,84; intervalle de confiance à 95 % 0,80-0,87) des AC lors de STEMI. Le RTI n'était pas associé au nombre provincial de cas de COVID-19. Nous avons observé une réduction de 26 % (RTI 0,74; intervalle de confiance à 95 % 0,61-0,89) de l'utilisation de pompes à ballonnet intra-aortique lors de STEMI. L'utilisation d'une pompe Impella et les complications mécaniques après les STEMI étaient extrêmement rares.

Conclusions : Nous avons observé une diminution modeste de 16 % de l'utilisation des AC lors de STEMI durant la première vague de la pandémie au Canada, soit une diminution plus faible que ce que les autres pays ont signalé. Le nombre provincial de cas de COVID-19 n'a pas influencé cette réduction.

For the management of ST-elevation myocardial infarction (STEMI), reperfusion therapy with primary percutaneous coronary intervention has become standard therapy when it is accessible and can be provided in a timely fashion.¹ As a result of the first COVID-19 pandemic wave, several publications that gathered single-or multi-centre experience from diverse regions have reported significant reductions in STEMI invasive care, measured as catheterization laboratory activations, acute coronary angiography (CA), or hospitalization for STEMI, ranging from 23% to 76%²⁻¹⁴ compared to control periods, with the sole exception of New Zealand,¹⁵ where no change was observed. Proposed explanatory hypotheses include over-observance of lockdown policies (although such policies were never meant to discourage patients from seeking medical attention in case of emergency), reduced or delayed emergency visits due to patient fears of contracting COVID-19 in the medical system, increased use of fibrinolytic therapy

in a period with limited human and physical resources, and increased out-of-hospital mortality. Anecdotal evidence supports increased delayed or late presentations, leading to increased mechanical complications.¹⁶⁻²⁰

The first wave of the COVID-19 pandemic has not occurred homogeneously throughout Canada. Although the province of British Columbia was affected first, Quebec and Ontario experienced the greatest infection burden during the first wave of the pandemic. Nevertheless, a countrywide lockdown was imposed by all provinces from mid-March to May, with progressive unlocking throughout May and June from region to region. Whether the regional caseload had any impact on patient or healthcare provider behaviour is not known.

Based on shared subjective impression among the interventional cardiology community, we hypothesized that invasive management for STEMI may have decreased during the worst phase of the pandemic (March 1 to May 31, 2020) compared

with the same months in 2018 and 2019. We also hypothesized that use of mechanical support devices for STEMI would be greater, as a consequence of presentation delays or worse clinical features, and we assumed an increase in mechanical complications during the pandemic period compared with the previous months. Finally, we hypothesized that the regional intensity of the pandemic, as reflected by the COVID-19 caseload, may be associated with CA for STEMI volumes.

Methods

We performed an observational health-services research study utilizing a survey sent through the Canadian Association of Interventional Cardiology/Association Canadienne de Cardiologie d'Intervention office to all cardiac catheterization laboratory directors, requesting that they provide the volume of CA used for STEMI between March 1, 2020 and May 31, 2020 (pandemic period), and from March 1, 2019 to May 31, 2019, and March 1, 2018 to May 31, 2018 (control periods). Activation of the laboratory for other urgent indications, including unstable angina or non-STEMI issues, was not part of our research question. Data extraction from catheterization laboratory databases, STEMI activation logs, administrative hospital databases, or detailed angiographic and/or chart reviews provided the source documentation. The questionnaire was constructed within an Excel spreadsheet, as the case report form could be downloaded and printed for ease of completion. Data was extracted by administrative assistants, research coordinators, or physicians, depending on location. However, each author verified and confirmed the accuracy of their local data, to the best of their knowledge. For the same periods, the number of left ventricular or circulatory support devices, such as an intra-aortic balloon pump (IABP), an Impella axial pump (any type) (Abiomed, Danvers, MA), or veno-arterial extra corporal membrane oxygenation (VA-ECMO), used for STEMI was also provided. For the pandemic period, laboratories provided the number of cases for which a ventricular septal defect or a papillary muscle rupture was diagnosed, as compared with a full year prior (as these events are rare). Due to the nature of the data collected (anonymized administrative data) and shared by centres, this study received a waiver for formal research ethics board review at McGill University Health Centre, with which one centre requested a data-sharing agreement. Data were collected through the Canadian Association of Interventional Cardiology/Association Canadienne de Cardiologie d'Intervention to populate the final dataset. Once all data were collected, aggregate data were transferred to the primary investigator for statistical analysis.

Data analysis

In each Canadian province, the number of STEMI cases during the first wave of the pandemic (2020) was compared to the average number of STEMI cases during the control period (ie, the same months during 2018-2019). For left ventricular or circulatory support, we compared the number of times an IABP, an Impella pump, or VA-ECMO was used for STEMI during the first wave of the pandemic vs during control periods. Canada-wide

comparisons were also calculated for both STEMI and left ventricular/circulatory support. All comparisons were based on incidence rate ratios (IRRs), defined as the ratio of the number of cases in 2020 vs 2018-2019, per province, and then for the whole country, assuming the size of the underlying population remained the same in the 2 periods being compared. For each IRR, 95% confidence intervals (CIs) were calculated under the assumption that the number of cases follows a Poisson distribution in each time period. Because of low counts, we did not perform statistical comparison for mechanical complications.

We finally assessed whether the intensity of the pandemic in each province was associated with the volume of STEMI cases. To answer this question, we divided provinces in 3 pandemic-intensity groups: provinces with the highest COVID-19 caseload (Quebec and Ontario) were assigned an intensity index of 3; provinces with a moderate caseload (Alberta and British Columbia) were assigned an index of 2; and lower-caseload provinces (all others) were assigned an index of 1. To test for a trend in lower IRR as a function of the pandemic-intensity index, a χ^2 test of trend was performed.

Results showing 95% CIs excluding the null value or *P* values < 0.05 were considered statistically significant. Analyses were performed using the R Statistical Software environment (Vienna, Austria).

Results

Questionnaires were sent on June 1, 2020. By October 15, 2020, we had received data from 41 (98%) of the 42 Canadian hospitals equipped with a cardiac catheterization laboratory. Only one laboratory did not provide data within the allocated time frame.

Coronary angiography for STEMI

Table 1 and Figure 1 show the main study results. The size of the square in Figure 1 indicates the sample size. Overall, there was a 16% (IRR 0.84; 95% CI 0.80-0.87) reduction in CA performed for STEMI during the first 3 months of the pandemic, compared to control periods. From west to east, Alberta (IRR 0.82; 95% CI 0.73-0.93), Saskatchewan (IRR 0.72; 0.59-0.89), Manitoba (IRR 0.80; 95% CI 0.64, 0.99), Ontario (IRR 0.80; 95% CI 0.74-0.85), and Quebec (IRR 0.86; 95% CI 0.78-0.95) observed significant reductions. Variation in other provinces did not reach statistical significance. Figure 2 shows a comparison by provincial severity of

Table 1. Coronary angiography for ST-elevation myocardial infarction

Province	Pandemic volume	Pre-pandemic volume	IRR	95% CI
British Columbia (BC)	348	373.0	0.93	0.81–1.08
Alberta (AB)	497	604.5	0.82	0.73–0.93
Saskatchewan (SK)	154	214.0	0.72	0.59–0.89
Manitoba (MB)	148	185.0	0.80	0.64–0.99
Ontario (ON)	1346	1692.5	0.80	0.74–0.85
Quebec (QC)	723	841.5	0.86	0.78–0.95
New Brunswick (NB)	136	152.5	0.89	0.71–1.12
Nova Scotia (NS)	208	197.0	1.06	0.87–1.28
Newfoundland (NL)	46	50.0	0.92	0.62–1.37
Canada	3606	4310.0	0.84	0.80–0.87

CI, confidence interval; IRR, incidence rate ratio.

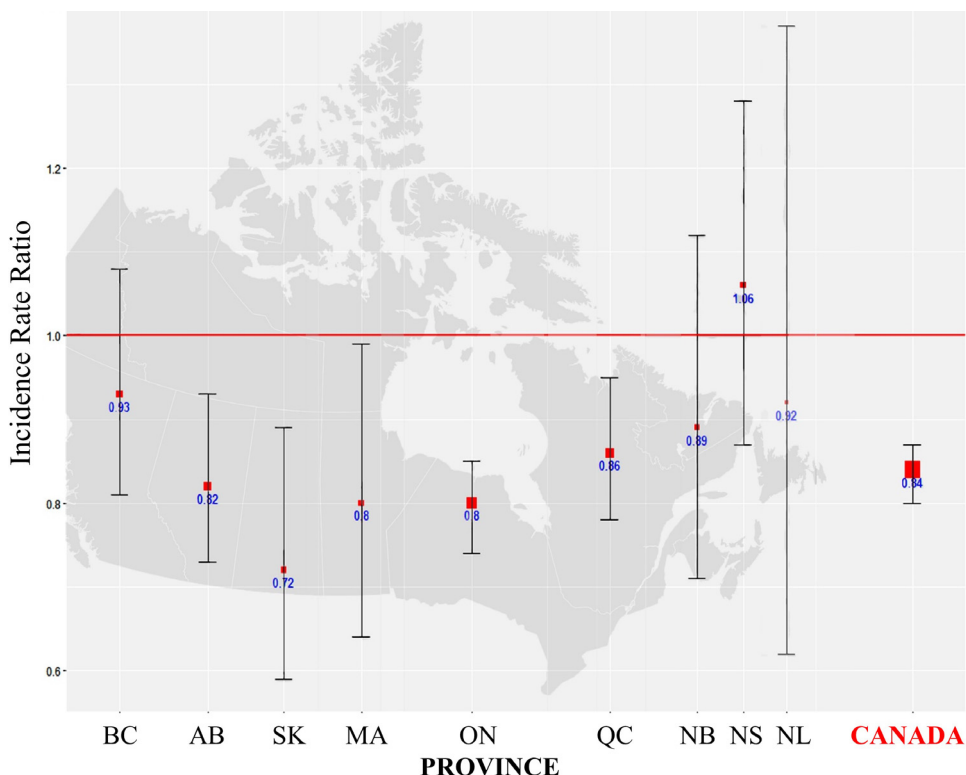


Figure 1. Variation in coronary angiography in March, April, and May of 2020 compared to the same months in 2018 and 2019, by province providing the service. Box and “whiskers” plot: **box** size reflects sample size, and **whiskers** indicate the 95% confidence interval around the incidence rate ratio estimates. AB, Alberta; BC, British Columbia; MA, Manitoba; NB, New Brunswick; NL, Newfoundland-Labrador; NS, Nova Scotia; ON, Ontario; QC, Quebec; SK, Saskatchewan.

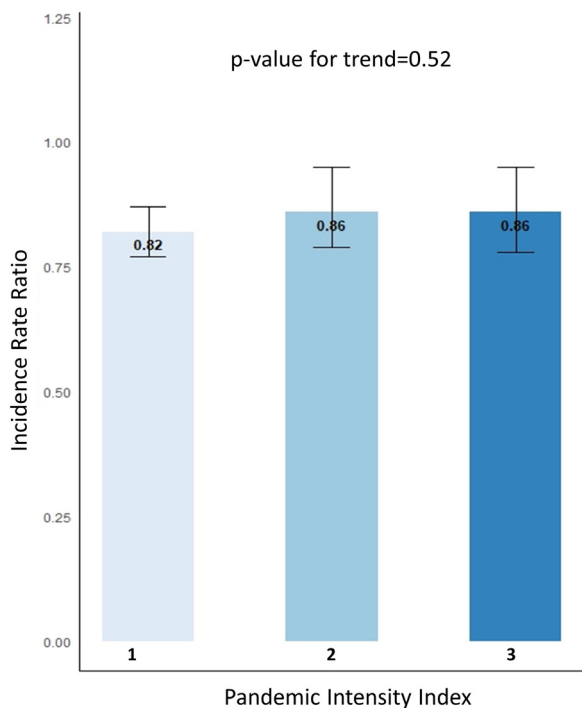


Figure 2. Incidence rate ratios as a function of the pandemic intensity index.

the pandemic. As displayed, we did not observe any significant trend ($P = 0.52$) in decrease of the IRR by COVID-19 case-load.

Mechanical left ventricular or circulatory support

Table 2 shows IRRs for the whole country, as counts were small for each centre. We did not observe any significant variation in the use of Impella pumps or VA-ECMO support during the pandemic, compared to control periods, although counts were very low and clinically meaningful increases or decreases cannot be excluded. However, there was a significant 26% reduction (IRR 0.74; 95% CI 0.61-0.89) in the use of IABPs in STEMI during the pandemic, compared to the same months in 2018-2019.

Mechanical complications post-STEMI

In the whole country, 7 cases of ventricular septal defect and 9 cases of papillary muscle ruptures were identified during the 3 first months of the pandemic, compared to 30 and 13 cases, respectively, in the year prior to the pandemic, which amount to 7.5 cases of ventricular septal defect and 3.25 cases of papillary muscle rupture for a similar 3-month control period. Because of the statistical instability associated with these low counts, we did not perform any statistical comparisons.

Table 2. Mechanical support for ST-elevation myocardial infarction

Type of support	Number of units used during pandemic	Number of units used in 3-month control period	IRR for Canada	95% CI
IABP	194	263.0	0.74	0.61–0.89
Impella	14	7.5	1.87	0.77–4.53
VA-ECMO	17	14.4	1.17	0.58–2.36

CI, confidence interval; IABP, intraaortic balloon pump; IRR, incidence rate ratio; VA-ECMO, veno-arterial extra corporeal membrane oxygenation.

Discussion

In this national survey, which gathered data from 98% of Canadian cardiac catheterization laboratories, we observed a modest but statistically significant 16% decrease in use of CA for STEMI during the first wave of the pandemic, compared to the same months in the 2 previous years, a decrease lower than that reported in other countries. We could not demonstrate any association between higher CA use reductions and higher COVID-19 caseloads. Also, we did not observe any increase in the use of mechanical support for STEMI, but rather a decrease in the use of IABPs, following the reduction in CA use for STEMI. This does not support our original hypothesis that more higher-risk STEMIs from delayed presentation would require more invasive mechanical support. Because of low counts, we could not draw any conclusion about the variation in Impella pump or VA-ECMO use, or in mechanical complications.

The 16% reduction in Canada is among the lowest reductions in CA use reported in the world. Geographically closer to Canada, a more important reduction in the number of activations for STEMI (29%), CA (34%), and primary percutaneous coronary intervention (20%) were observed in 18 high-volume US centres.²¹ Due to these concerns, a reappraisal of STEMI care in the context of COVID-19 has been suggested.^{22, 23} Although it would be tempting to conclude that universal medical access mitigated risk-averse behaviour from patients in Canada, data from the large British Cardiovascular Intervention Society registry in the UK, also in a public healthcare system, reported a larger 43% decline.²⁴ A lower absolute number of COVID-19 cases in Canada may have resulted in fewer Canadian patients being discouraged from seeking medical attention compared to UK or US patients, where the level of COVID-19 mortality was higher. Our data show the modest reduction to be similar across provinces, despite the different COVID-19 caseload. Thus, the intensity of the pandemic did not seem to influence the observed reduction in CA use.

Beyond reduction in incidence of CA for STEMI, delayed presentations have been more common during the first wave,^{25, 26} with increases in overall symptom-to-hospital delays,^{24, 27} along with increased out-of-hospital cardiac arrest rates,¹¹ and anecdotal evidence of increased delayed presentations and mechanical complications.^{16–20} However, the incidence of cardiogenic shock has not increased in a large Danish registry.²⁸ In one Canadian study, the incidence of STEMI admission was not reduced during the pandemic period in Montreal, but unstable STEMI presentations and worse in-hospital course were more frequent,²⁹ data we could not replicate with a much larger and broader sample size. Our study is the first to gather usage data for left ventricular or circulatory support devices. We did not observe any significant increase in the use of left ventricular or circulatory support, but rather a

consistent decrease in the use of IABPs across all provinces, larger than the decrease in use of CA, which is surprising, to some extent, given the increase in shock patients during the pandemic. Such reduction cannot be explained by preferential usage of the Impella pump, which remained low across the country. Although our data suggest a true reduction in cardiogenic shock patients reaching the catheterization laboratory, the phenomenon is unlikely to be explained by a true reduction in the incidence of severe STEMI. A more plausible explanation is an increased mortality rate among the sickest patients who did not present at the catheterization laboratory during the pandemic. Although an increase in mechanical complication may have occurred, especially for papillary muscle rupture, the very low number of events precludes any strong conclusion.

Our study has other limitations to acknowledge. First, it is a survey on resource use, without patient-level data. Patient-related outcomes and patient perspectives were not captured by the design of this study. Although such a design alleviated the need for research contracts and approval nationwide, it limited the scope of possible analyses. Second, data source verification was not performed, and we could rely on only best estimates from the various laboratories. Despite this issue, systematic bias is unlikely. Third, the COVID-19 pandemic is now affecting all provinces more uniformly, except for the so-called Maritime bubble (NB, NS, and NL), where caseload remains low. A survey performed at this time of the year could have yielded different results. Fourth, we relied on catheterization laboratory data. As mentioned earlier, the adverse effect of the pandemic may have increased mortality from STEMI prior to patients presenting in the hospital. Sixth, mechanical complications and the need of an Impella pump and VA-ECMO were too infrequent to use these as a surrogate for medical assistance delay. Moreover, the unequal access to Impella pumps or VA-ECMO throughout the country, which are available in less than 20% of laboratories, further reduced the power to detect any real change in use during the pandemic. Finally, our study design could not assess whether the pandemic altered the type of patient presenting for STEMI care. As mentioned earlier, although no increase in IABP use was observed, we cannot exclude the possibility of an increase in late presenters and higher-risk STEMIs leading to a higher level of out-of-hospital death. Also, the volume of CA might not accurately reflect patient behaviour in seeking medical attention, as some patients might have presented to centres without primary percutaneous coronary intervention capacity and been managed with thrombolytics rather than transferred for primary percutaneous coronary intervention. Only a detailed per province evaluation of hospitalization for STEMI, including lethal cases, could answer that question.

Conclusion

We observed a modest but significant 16% decrease in use of CA for STEMI during the first wave of the pandemic, lower than that reported in other countries. Such a decrease may be attributable to patient behaviour, reduction in volume of transfer for CA, or increased mortality prior to CA. Although instances of mechanical complications were higher, we could not draw any conclusion regarding the effect of the pandemic on mechanical complications from STEMI or use of Impella pumps, given low counts. The reduction in use of CA for STEMI was accompanied by a decrease in the use of IABPs, which most likely suggests an increased mortality level among the sickest patients—that is, that they did not ever reach the catheterization laboratory. Finally, the intensity of the pandemic in each province, which was much less lethal than in other parts of the world at that time, was not associated with the reduction in CA use observed. A Canadian study using pre-hospital and hospital clinical or medico-administrative patient-level data, gathering all treatments, including fibrinolytics and primary angioplasty, with related outcomes would be required to further illuminate our findings.

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Disclosures

The authors have no conflicts of interest to disclose.

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