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Collaborative Heart Attack Management Program (CHAMP): use of prehospital thrombolytics to improve timeliness of STEMI management in British Columbia

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ABSTRACT

Coronary artery disease is the second leading cause of death in Canada. Time to treatment in ST-elevation myocardial infarction (STEMI) is directly related to morbidity and mortality. Thrombolysis is the primary treatment for STEMI in many regions of Canada because of prolonged transport times to percutaneous coronary intervention-capable centres. To reduce time from first medical contact (FMC) to thrombolysis, some emergency medical services (EMS) systems have implemented prehospital thrombolysis (PHT). PHT is not a novel concept and has a strong evidence base showing reduced mortality.

Here, we describe a quality improvement initiative to decrease time from FMC to thrombolysis using PHT and aim to describe our methods and challenges during implementation. We used a quality improvement framework to collaborate with hospitals, EMS, cardiology, emergency medicine and other stakeholders during implementation. We trained advanced care paramedics to administer thrombolysis in STEMI with remote cardiologist support and aimed to achieve a guideline-recommended median FMC to needle time of <30 min in 80% of patients. Overall, we reduced our median FMC to needle time by 70%. Our baseline patients undergoing in-hospital thrombolysis had a median time of 84 min (IQR 62–116 min), while patients after implementation of PHT had a median time of 25 min (IQR 23–39 min). Patients treated within the guideline-recommended time from FMC to needle of <30 min increased from 0% at baseline to 61% with PHT. Return on investment analysis showed $2.80 saved in acute care costs for every $1.00 spent on the intervention.

While we did not achieve our goal of 80% compliance with FMC to needle time of <30 min, our results show that the intervention substantially reduced the FMC to needle time and overall cost. We plan to continue with ongoing implementation of PHT through expansion to other communities in our province.

PROBLEM

Coronary artery disease affects more than 8.5% of Canadians over the age of 20 and is the second leading cause of death in Canada.[1] Outcomes following ST-elevation myocardial infarction (STEMI) are directly related to total ischaemic time.[2] The greatest mortality benefit from reperfusion occurs early in the disease course and decreases exponentially with time.[1] A 2013 meta-analysis demonstrated a 4%–12% increased risk of new-onset heart failure for every 1-hour delay in coronary reperfusion.[3] Similarly, there is a linear relationship between delay to treatment and mortality in patients with STEMI, especially those presenting with cardiogenic shock.[4]

In out-of-hospital patients with STEMI, primary percutaneous coronary intervention (pPCI) is preferred if transport time to a percutaneous coronary intervention (PCI)-capable centre is less than 60 min,[5] with a goal of pPCI within 120 min of first medical contact (FMC). This poses a challenge in the province of British Columbia (BC), Canada, as many communities lay outside of the 60 min transport window. These communities rely on in-hospital thrombolysis followed by transfer to a PCI-capable centre as the primary treatment modality for patients with STEMI. Early thrombolysis paired with urgent or emergent PCI, depending on success of thrombolysis, is known as pharmacoinvasive therapy (PIT). This strategy for reperfusion is comparable to primary PCI.[6] The Canadian Cardiovascular Society (CCS) guidelines recommend that thrombolytics be administered within 30 min of FMC (ie, FMC to needle time) if this approach is chosen.[5]

The Royal Inland Hospital (RIH), is a non-PCI-capable facility located in Kamloops, BC. Due to its geographical location, the mainstay of treatment is thrombolysis in eligible patients with STEMI. RIH is a tertiary care

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referral centre with a catchment area of more than 230 000 patients spread over more than 120 000 km^2.[7] The population density of two people per square kilometre is half of the national average and less than 1/15th the density of neighbouring USA.[8] The region's low population density means that patients often travel long distances via ground ambulance prior to receiving treatment. The prehospital system also has limited capability for air evacuation of these patients.

The province of BC is serviced by the British Columbia Ambulance Service, a multitiered emergency medical services (EMS) system under the authority of BC Emergency Health Services (BCEHS). BCEHS is the only provider of prehospital care in the province and is the single largest provider in Canada. Incidents received through 9-1-1 by BCEHS communications call takers are classified and prioritised using an internationally recognised scripted interview algorithm known as 'Medical Priority Dispatch System'. Once the condition is categorised, resource assignment is determined using the clinical response model (CRM). The CRM provides for six categories for assignment of resources for both emergency and non-emergency calls. The six categories are assigned a colour that indicates the resource and response type and also indicates the relative priority of the call, with purple being the highest priority, followed by red, orange, yellow and blue.

BCEHS responds to the needs of the majority of patients using two clinical roles: primary care paramedic (PCP) and advanced care paramedic (ACP). In locations where ACPs are available, and where the CRM indicates that ACPs are assigned (purple and red), then both PCP and ACP attend in a layered fashion.

Locally in Kamloops, PCPs provide immediate care responses to the majority of emergency calls, while ACPs provide an increased level of assessment and interventions and specialised care to specific targeted populations, including patients with possible acute coronary syndromes (red CRM). Out-of-hospital ECG acquisition and interpretation are performed by ACPs as standard of care, with identification and transmission of ECGs with suspected STEMI to prepare for in-hospital treatment. In BC, less than 10% of paramedics are able to acquire and interpret ECGs.

Based on an audit performed from December 2017 to October 2018 in our hospital, 20 patients with STEMI arrived from the out-of-hospital environment and subsequently received in-hospital thrombolysis. Target FMC to needle times (median 84 min, IQR 62–116) were not being attained within the national recommended time frame (0% of cases <30 min) using an in-hospital thrombolysis strategy. FMC, as similarly defined in the CCS 2019 Guidelines,[5] is the time of EMS arrival at scene (prehospital and includes whichever of ACP or PCP first arrival) or hospital registration ('walk in').

As such, we decided to use prehospital thrombolysis (PHT) as a strategy to reduce time from FMC to thrombolysis in patients with STEMI by bringing the required intervention closer to the point of FMC and mitigate the effect of long transport times and in-hospital delays. PHT administered by paramedics in the field has been implemented widely around the globe with improved outcomes[9] but has not previously been used in BC. This initiative was funded by BCEHS and Interior Health and received physician quality improvement funding through the Specialist Services Committee of BC.

SMART (Specific, Measurable, Attainable, Realistic, Timebound) Aim

Our aim was to use PHT to meet the CCS guideline target for patients with STEMI of FMC to thrombolysis time of <30 min in 80% of patients with STEMI.

BACKGROUND

It has been established that PIT has an equivalent outcome to pPCI.[10–13] A recent meta-analysis demonstrated a 48% increased risk of cardiogenic shock in patients who received pPCI compared with PIT when presenting to hospitals without PCI capabilities.[14]

Thrombolysis has been shown to be more effective and safer if given sooner after symptom onset and FMC.[5] Patients treated less than 2 hours after symptom onset with thrombolysis have lower incidences of heart failure,[15] smaller infarct sizes and less morbidity.[16] When thrombolytics can be administered within 1 hour of symptom onset, 30% of STEMIs can be aborted.[16] PHT results in a significant reduction in the time from symptom onset to treatment of 28–78 min[11 16] and up to a 50% reduction in FMC to treatment time.[17] Thus, by shortening time to administration through PHT, meta-analyses have estimated relative in-hospital mortality benefits of 17% over in-hospital thrombolysis.[12]

Thrombolysis is associated with specific risks. Most importantly, thrombolysis has a clinically important risk of significant bleeding.[2 11 12] The most concerning location for bleeding is intracranial; however, other sites include the gastrointestinal tract, respiratory tract or spinal canal. Other relevant adverse events potentially occurring with administration of thrombolysis are allergic reaction or anaphylaxis, angioedema, arrhythmia and hypotension. Available data have demonstrated the risk of such safety outcomes is no different when these therapies are administered in the in hospital setting versus prehospital setting.[18–20] Moreover, the risk of major bleeding appears to be no different with a pharmacoinvasive strategy when compared with primary PCI.[6]

MEASUREMENT

Our study included a trial of 13 patients who received PHT. This initial trial was limited in size due to funding constraints that restricted access to the thrombolytic medication tenecteplase (TNK). Given that the design of this project was as a quality improvement initiative, we did not perform a power calculation. Rather, we concentrated

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on frequent Plan-Do-Study-Act (PDSA) cycles and re-evaluation of our methods.

Our primary outcome indicator was FMC to needle time. Specifically, we aimed to achieve FMC to needle time of <30 min in 80% of cases of PHT. We defined FMC as the time of first medical personnel that arrived to assist the patient regardless of level of training (PCP or ACP). However, it is worth specifically noting that our PCPs (who make up 90% of paramedics) are unable to acquire ECGs.

The correlation between time to treatment and outcomes is well established with numerous well-powered studies.[2–4 12 13 15] We did not feel it was appropriate to report specific outcomes in detail, given our small sample size. Our study size was too small to assess for patient-centred end points commonly measured in larger studies, and with an N of 13 reporting these relatively rare outcomes would be misleading regardless of whether they showed positive or negative results. Instead, we focus on time to treatment, which can still be assessed in a statistically accurate manner and which has been shown to be directly related to mortality.[2–5 12 13 15] As a result, we did not perform power calculations and decided on our study size based on principles of quality improvement.

To establish baseline data, we prospectively measured FMC to needle time in 20 patients with STEMIs treated with in-hospital thrombolysis. Data were collected between December 2017 and October 2018 by a single clinical pharmacist. This was a convenience sample of all patients admitted or transferred to RIH emergency department during working hours. Patients who did not come to RIH by ambulance were excluded. Our baseline measurement showed that we were meeting the CCS guideline target of FMC to needle time of <30 min 0% of the time. The FMC to needle times of these patients were then compared with the times recorded for the patients enrolled in our trial.

Outcomes of our 13 study participants were collected through a collaborative effort. The FMC to needle time was collected by the ACPs on the ambulance response crew and shared by BCEHS after each case. Patients who received PHT were followed up in-hospital by the cardiac pharmacist, who recorded in-hospital patient outcomes. We also assessed safety outcomes including mortality, cardiac arrest, bleeding, shock, heart failure and ventricular fibrillation (VF)/ventricular tachycardia. There were zero eligible patients who declined to participate in the study.

DESIGN

Our project started with regular meetings between key project members, including RIH cardiologists, emergency department (ED) physicians, a physician QI consultant, RIH pharmacy and members of BCEHS. We obtained expert opinions from individuals in other provinces with similar PHT programmes. Patients or the public were not involved in the design, conduct or reporting of this study.

Together, we created a comprehensive evidence-based protocol that allowed ACPs to deliver thrombolytics in the field. This protocol outlines key components of the history (including contraindications to thrombolytics), physical exam and ECG findings. It then directs ACPs to contact the 24/7 on-call cardiologist to review the case and receive approval for administration of thrombolytics. A script for establishing informed consent and doses for medication administration was also included on the protocol.

We included a half-dose thrombolytic protocol for patients over the age of 75, based on previous research demonstrating a lower incidence of intracranial haemorrhage (ICH).[20] Medications administered included (in order of administration) enoxaparin intravenous bolus, TNK intravenous bolus, subcutaneous enoxaparin and oral clopidogrel (online supplemental appendix 1). These medications were supplied to the paramedics in sealed kits prepared by the clinical pharmacist. In this kit, medications were placed in individually labelled bags along with the supplies required for administration (flushes and alcohol swabs). Coloured auxiliary labels were used to identify route of administration (intravenous or subcutaneous) for enoxaparin syringes. A copy of the protocol was also provided in the kit.

We engaged our ACPs to develop and implement a comprehensive curriculum focusing on enhancing STEMI recognition and management and thrombolytic administration. The education series was attended by the cardiologists who would be receiving the ACP's calls, appointed emergency physicians who would be receiving the patient in the ED and the clinical pharmacist who created the medication kits which were distributed to the ambulances. These sessions used didactic lectures, case-based learning and simulation-based training, and were recorded for future training purposes.

The protocol went live on 1 September 2019. We had multidisciplinary meetings following every one to four cases. These included our ACPs, a member of our cardiology team, physician QI consultant, cardiac clinical pharmacist, members of our ED and lead project team members to discuss the outcomes of the event. Each of these meetings acted as a PDSA cycle, as we used this as an opportunity to receive feedback from project members to help improve the protocol.

Our goal was to provide a model and proof of concept for other communities to adopt this model. A major barrier to potential implementation at other sites is the availability and buy-in of a local cardiology group. For this project, the cardiology team was driving the initiative forward and had adequate physician numbers to cover the call schedule. However, this is certainly not true in many centres where PHT may be of benefit, and more distanced solutions (eg, cardiology on-call at a tertiary referral centre) may be needed. Within many centres across BC, emergency physicians decide on who will receive thrombolysis for STEMI and therefore could

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likely also be used as consultants in communities where cardiology is not available on-call.

Specifically, we ensured adequate training and support of our ACPs to prevent patient harm. This was achieved through comprehensive training including didactic lectures, a simulation session, circulation of the protocol to ensure familiarity and 24/7 cardiology support. The cardiologist on call was ultimately responsible for collecting all of the relevant information from the ACP to ensure an appropriate clinical decision was made for each patient. This is very similar to the process by which a physician-to-physician telephone consult would be processed to perform thrombolysis at a remote ED as well.

We performed a return on investment (ROI) analysis to evaluate the cost-effectiveness of our intervention. We met periodically with senior executives to discuss our initiative and measures required to ensure sustainability. We have also presented our work at local and regional meetings, including our local medical staff association, health authority advisory committee, the regional acute myocardial infarction meeting, and our regional cardiac services programme to acquire local and regional support for sustainability.

SQUIRE reporting guidelines for quality improvement studies were used in the preparation of this manuscript.[21]

STRATEGY

PDSA cycle 0 (simulation)

The first use of the protocol was completed in a video-recorded simulation scenario where two ACPs went through all the steps of the protocol using a high-fidelity simulation mannequin, our real ECG recording and transmission software, our hospital switchboard, an on-call cardiologist and our newly developed medication kit.

Changes identified from this session included the elimination of extraneous information and making key information, such as dosing and the protocol for contacting the cardiologist, more user friendly. Familiarity with the new protocol and medication kit was also identified as an issue, so we supplied extra sample kits at the paramedic station so workers could familiarise themselves with them in advance. Positive feedback was received as paramedics felt more comfortable with the kit on future calls.

PDSA cycle 1 (case 1)

In our first case, the main challenge identified involved a delay in contacting cardiology, as the paramedic had to call both the ED to notify them of their pending arrival and hospital switchboard in order to contact the on-call cardiologist to discuss the case. We changed our process so only one call to the ED is required for prenotification and to contact the cardiologist. This simplified logistical considerations in an already busy and time-constrained situation.

We did not achieve the CCS goal of FMC to needle time of <30 min.

PDSA cycle 2 (case 2)

The first challenge in this case was that the ambulance medication kit had been disassembled. As a result, a medication administration error occurred when the subcutaneous dose of enoxaparin was given as an intravenous bolus. This error was disseminated to other ACPs as a potential point of confusion in order to reduce further complications. Additionally, all boxes on the ambulances were secured with tamper-proof packaging. Two kits were made available on each ambulance, such that if one had been opened, the other could be used.

A major delay in this case was from FMC (PCP arrival with no ability to acquire and transmit an ECG) to ACP arrival. This unfortunately is a difficult to correct issue because it requires greater availability of ACP crews. This was noted for general staffing considerations, but no specific changes were made to the protocol.

Additionally, paramedics had difficulty contacting the on-call cardiologist as the ambulance was out of cell phone range. In the future, similar cases will be managed by initiating transport to the hospital until such time that the paramedic has cell service and can place the call.

We did not achieve the CCS goal of FMC to needle time of <30 min.

PDSA cycle 3 (case 3)

In the third case of PHT, the main challenge was that the ACP was 'depaired', meaning the case was managed by a single ACP with assistance from a PCP provider unfamiliar with the study protocol. It was decided that ACPs being paired was a priority for these cases, and this information was disseminated to the paramedic dispatch service.

We achieved the CCS goal of FMC to needle time of <30 min.

PDSA cycle 4 (case 4)

In the fourth case of PHT, the patient had an ICH after admission to the hospital and subsequent rescue PCI. A formal review of the case was completed through a quality assurance forum created by the cardiology team, who concluded that the location of the thrombolysis did not contribute to the adverse outcome and that a similar decision likely would have been made in-hospital. A variety of potentially contributory factors were identified, including the patient being therapeutically anticoagulated in the community, over the age of 75, and receiving additional doses of antiplatelet medication in-hospital and prior to angiography. The on-call cardiologist was aware of these factors prior to making the decision to proceed. We decided not to exclude patients with relative contraindications to thrombolysis from our trial. Ultimately, there were no changes to the protocol as a result of this event.

We achieved the CCS goal of FMC to needle time of <30 min.

PDSA cycle 5 (cases 5, 6 and 7)

These cases were reviewed and no major issues were identified.

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We achieved the CCS goal of FMC to needle time of <30 min in all three cases.

PDSA cycle 6 (cases 8, 9, 10 and 11)

The major issue with cases 8 and 10 was a delay from FMC (PCP arrival with no ability to acquire and transmit 12-lead ECG) to ACP arrival (similar to case 2). Again, this was passed on for consideration by BCEHS management, and the primary solution will be increased staffing or reallocation of ACP resources in order to improve availability for these calls.

We achieved the CCS goal of FMC to needle time of <30 min in cases 9 and 11, but not in cases 8 and 10.

PDSA cycle 7 (cases 12 and 13)

Case 12 represented an interesting ethical dilemma of providing significant time-sensitive intervention in an information-limited environment.

The patient presented as an inferior STEMI ~4 hours after the stated time of symptom onset. They were appropriately given thrombolysis as per direction of the cardiologist on-call. They subsequently did not achieve reperfusion and developed cardiogenic shock requiring intubation and transfer to a tertiary care centre, where they were declined for mechanical circulatory support and subsequently had care withdrawn.

This case was complicated because, in retrospect, it was discovered that this patient had a moderate underlying developmental delay and mental health concerns. It was also discovered later that the patient likely had fluctuating symptoms for over a week, not 4 hours. This additional information was not apparent until long after thrombolysis.

Discussion focused on patient capacity to consent, and it was concluded that in this case, the patient certainly understood the risk and benefit of treatment prior to administration. However, it was decided that in the future, any patient with questionable ability to consent should be transported to hospital where further information can be obtained prior to the thrombolysis.

Lastly, it was noted that if patients receive thrombolysis after >12 hours of symptom duration they are at higher risk of mechanical complications. While these complications weren't the reason for the patient's poor outcome, the study consent script was amended to include a statement explaining that "if treatment is given >12 hours after onset of symptoms, treatment may cause more harm than benefit."

We achieved the CCS goal of FMC to needle time <30 min in both cases.

RESULTS

A summary of our baseline patient characteristics is shown in table 1.

The number of patients treated within the CCS recommended time from FMC to needle of <30 min increased from 0% at baseline to 61% with PHT implementation but did not achieve our goal of 80% compliance with guideline targets.

Table 1 Baseline characteristics of patients receiving in-hospital and PHT

Characteristics	In-hospital thrombolysis n = 20	PHT n = 13
Age (years), median	68	70
Sex, male, n (%)	17 (85)	10 (77)
Medical history, n (%)		
Hypertension	8 (40)	8 (63)
Diabetes mellitus	7 (35)	2 (15)
Dyslipidaemia	5 (25)	7 (54)
Smoker	8 (40)	7 (54)
Chronic kidney disease	3 (15)	1 (8)
Any previous CAD	4 (20)	4 (31)
Previous MI	3 (15)	3 (23)
Previous coronary stent	1 (5)	3 (23)
Previous CABG	1 (5)	1 (8)
ECG localisation of STEMI, n (%)		
Anterior	6 (30)	3 (23)
Inferior	14 (70)	4 (31)
Posterior	3 (15)	1 (8)
Lateral	1 (5)	2 (15)

Note: Each patient may have more than one characteristic.
CABG, coronary artery bypass graft; CAD, coronary artery disease; MI, myocardial infarction; PHT, prehospital thrombolysis; STEMI, ST elevation myocardial infarction.

However, our results show that our intervention reduced the median FMC to needle time by 70% in comparison to our baseline data (figure 1). Our baseline patients who received in-hospital thrombolysis had a median FMC to needle time of 84 min (IQR 62–116 min), while patients after implementation of PHT had a time of 25 min (IQR 23–39 min). ACP arrival to needle time was <30 min in 92% of cases after prehospital thrombolytic implementation. ACP arrival to ECG of <10 min was achieved in 100% of cases.

Table 2 details outcome variables in the in-hospital and PHT groups. Eleven of 13 (85%) patients administered PHT in this trial met reperfusion criteria within 90 min of administration, though several subsequently reoccluded and required rescue PCI. Several adverse events occurred; however, none were directly attributed to thrombolysis aside from the incident of ICH in case 2. The patients in cases 2 and 13 died, one due to ICH and one due to refractory cardiogenic shock. Outside of case 2, no other bleeding complications were reported. Two patients suffered cardiac arrests due to VF after thrombolysis but subsequently did well after rescue PCI. Nine of 13 (69%)

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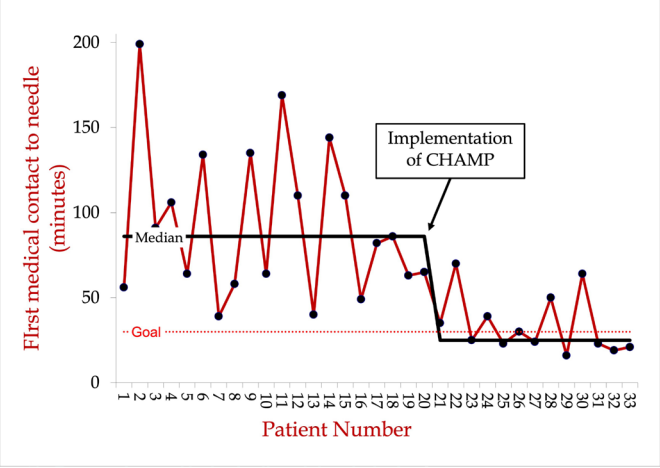

Figure 1 Run chart comparing first medical contact to needle time in baseline patients with in-hospital thrombolysis (N 1–20) and trial patients with prehospital thrombolysis (N 21–33). CHAMP, Collaborative Heart Attack Management Program.

patients had stenting, with 3 patients having unsuitable anatomy and 1 who had completely recanalised his or her coronary arteries.

We monitored for unexpected adverse effects or changes due to the protocol used. The only patient safety event related to the study was our one patient who suffered an ICH. Please see the PDSA cycle 4 (case 4) section, but in short, this was felt to be an inevitable possible complication of treatment and not felt to be a result of a fault in the system design.

LESSONS AND LIMITATIONS

Through this project, we learnt that PHT is a reasonable approach to reducing time to thrombolysis in the BC healthcare environment. We did not achieve our aim of meeting CCS guideline target time of FMC to needle of <30 min in 80% of the patients; however, we did significantly improve on time to thrombolysis compared with our baseline. We also demonstrated that prehospital thrombolytics, which are well established therapies, can be safely administered in our local environment.

This project is important as in our evolving healthcare model there is an increasing need to work in multidisciplinary teams to address complex health problems. Gone are the days of ambulance services being a 'call and haul' service. Embracing and using their full potential as healthcare providers will allow us to optimise health outcomes for our patients.

Our project strengths include our objective primary outcome, which is derived from recorded times of arrival on scene and administration of thrombolysis. It is easily measured and has little risk of confounding or other influencing factors. Another strength was the number of PDSA cycles performed, which allowed significant adaption early in the project, and then subsequent cycles required fewer changes as the process became more streamlined.

As noted in our PDSA cycles, the most common contextual elements that impacted our ability to meet our targets were the inability of PCPs to acquire ECGs, availability of ACP units to respond to calls and the ability to contact the on-call cardiologist in a timely fashion. Some themes were recurrent (eg, difficulty contacting cardiology), while others were distinct issues.

In addressing the limitations of our study, we acknowledge that a sample size of 13 participants allows for limited interpretation of data. This small sample size certainly introduces the possibility that our outcomes are the result of chance or confounding within our intervention. As such, we will continue to evaluate the programme, moving forward to ensure our intervention remains effective. This limited sample size was due to restricted funding for the TNK medication, and we did recognise this at the beginning of the trial. As this trial showed this treatment can be safely administered in our local environment, we hope to gain funding to continue this project on a permanent basis, which would allow for more robust data. While each region in the province is unique in its distribution and availability of ACPs and PCPs, this model is replicable in all communities with at least one ACP available.

One major practical limitation to the expansion of our project elsewhere in the province is availability of ACP providers. While we are aggressively training more advanced providers, this process takes time and will remain a limitation. Unfortunately, PCP scope is restricted through the Emergency Medical Assistant Licensing Board in BC, and they are unable to provide treatment such as thrombolysis. However, efforts to expand scope for PCP STEMI care have been initially successful, such as a recent implementation of PCP ECG acquisition. As well, although the organisation endeavours to ensure calls receive an appropriate level of response (ie, PCP vs ACP), it was possible our FMC to needle times would be contingent on ACP availability within our region.

Table 2 Outcomes of patients receiving in-hospital thrombolysis and PHT

Outcome	In-hospital thrombolysis N = 20	PHT N = 13
Survival, n (%)	19 (95)	11 (85)
Hospital length of stay (days), median (IQR)	4 (3–8)	3 (3–4)
Achieved clinical reperfusion	12 (60)	11 (85)
Received coronary intervention (stent or CABG)	16 (80)	9 (69)
VF/VT, n (%)	1 (5)	2 (15)
Heart failure, n (%)	2 (10)	2 (15)
Shock, n (%)	5 (25)	4 (31)
Major bleeding, n (%)	1 (5)	1 (8)

CABG, coronary artery bypass graft; PHT, prehospital thrombolysis; VF, ventricular fibrillation; VT, ventricular tachycardia.

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Our baseline analysis may have been subject to selection bias both due to small sample size as well as it represented a convenience sample collected during the working days of our pharmacist. Lastly, given that the project was implemented over several years, there is a chance that the baseline and intervention may have had unknown confounders or changes influencing the outcomes. We did not have any major changes, however, to our cardiac management programme during that time period except for this project.

This trial demonstrates that it is possible to improve time to thrombolysis using PHT. Generalisability is limited by our specific circumstances including type of EMS system, geography and cardiologist availability.

CONCLUSION

PHT has a known clinical benefit to patients experiencing STEMI, and here we demonstrate our quality improvement methodology. Our results are congruent with the background literature and support use of PHT as a means to decrease time from FMC to thrombolysis in settings without immediate access to pPCI.

With respect to our study aim, we demonstrated an improvement from 0% to 62% compliance with FMC to needle time of <30 min, which did not meet our target aim of 80% but was a significant improvement from baseline. Our median time from FMC to needle decreased from 84 to 25 min. We feel our primary measure was appropriate for our project, as it measures a relevant indicator of quality in STEMI management that is influenced by prehospital care. We did not adjust our aim during the study.

Our continuous quality improvement model allowed us to adjust the protocol after almost every case in order to refine our care delivery. This was a useful project and resulted in a positive experience for those involved. Anecdotal feedback from experienced physicians and ACPs felt that patients benefitted from the intervention.

> I firmly believe that this is a patient we would have been doing CPR on if we didn't have fibrinolytics. (ACP paramedic discussing case 7)

In addition to the clinical benefits detailed previously, we performed a ROI analysis comparing our baseline population (10 patients) with our first 10 patients undergoing PHT. We found in the ROI analysis that for every $1.00 spent on project implementation, there was an estimated return of $2.80. This equates to an ROI ratio of 2.80. The majority of cost savings was due to a reduced patient hospital and coronary care unit (CCU) length of stay compared with our baseline population. This calculation includes start-up costs, and we estimate that our ROI ratio will increase as the programme stabilises. Limitations of this analysis include the small sample size and an estimate of hospital and CCU mean cost per day, which may vary based on individual patient care requirements.

We feel this initiative demonstrates preliminary evidence that implementation of our protocol would significantly improve STEMI care in patients within other regions of BC by reducing the time delay to treatment. Our protocol can be used safely by ACPs with appropriate clinical governance. As such, we hope to expand our programme to other areas without timely access to pPCI. We have identified several hospitals that would benefit from such therapies. Our goal is to create a sustainable programme within our region prior to scaling up within other health authorities in BC.

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Patient consent for publication Not required.

Ethics No institutional ethical approval was required for this quality improvement initiative from a research ethics board, but ethical considerations were discussed with the working group and Health Authority. The initiative was approved through Interior Health with completion of a thorough privacy impact assessment to ensure patient confidentiality and safety. An ethical dilemma included insuring voluntary participation through informed consent. As a result, patients were informed of their participation in a pilot trial, and each patient appropriately consented to treatment in the prehospital setting using our verbal informed consent script (online supplemental appendices 1 and 3). Lastly, to ensure anonymity of participants, data were collected on a secure network drive that was password protected. Only deidentified patient data were shared with the rest of the study team.

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