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Improving door-to-needle times for patients presenting with ST-elevation myocardial infarction at a rural district general hospital

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ABSTRACT

Acute coronary syndrome is a common condition with a major global impact on healthcare resources and expenditure. International guidelines are clear in specifying that patients with acute ST-elevation myocardial infarction (STEMI) should receive urgent coronary reperfusion with either primary percutaneous coronary intervention (PCI) or thrombolysis. Although PCI is the gold standard in the treatment of STEMI, this is not always achievable in a rural hospital with no cardiac catheterization service. Consequently, local recommendations on STEMI management exist to promote timely administration of thrombolysis within 30 minutes of patient arrival. However, translating updated clinical policy into practice is a challenging and complex task that requires a multi-faceted approach with sustained engagement from local stakeholders.

Whilst working at a district general hospital in New Zealand, we noted a high incidence of patients presenting with STEMI receiving thrombolytic therapy outside the recommended 30 minutes door-to-needle time. Although final treatment was often only delayed by 5-10 minutes, we were concerned by the seemingly inconsistent management of these patients, often leading to unnecessary delays in the initiation of rapid reperfusion therapy.

We therefore championed a newly updated clinical guideline and promoted an early STEMI recognition and treatment algorithm in our hospital to raise awareness amongst staff and improve door-to-needle times. We introduced a number of simple low-cost interventions that included educational sessions for junior doctors and cardiac nursing staff, as well as posters and training on the use of a remote electronic ECG interpretation system to streamline out-of-hours management.

Overall, we found there to a be a steady improvement in door-to-needle times at our hospital, with 74% of patients receiving appropriate care within 30 minutes, compared to 43% prior to our interventions. This also translated to better patient outcomes.

This project forms part of an ongoing process to instigate quality improvements in the management of STEMI within rural institutions. Whilst we have demonstrated improved utilisation of a local STEMI guideline and streamlining of out-of-hours services, the key challenge remains to ensure that momentum of this project continues and forms a platform for sustainable clinical improvement in the long term.

PROBLEM

Whilst working at a rural 131-bed district general hospital in New Zealand, we noted a high incidence of patients presenting with ST-segment elevation myocardial infarction (STEMI) receiving thrombolytic therapy outside the recommended 30 minutes door-to-needle time. Although final treatment was often only 5-10 minutes outside guideline recommendations,[1] we were concerned by the seemingly inconsistent management of these patients, often leading to unnecessary delays in the initiation of rapid reperfusion therapy. Furthermore, commencement of appropriate secondary prevention medications, to reduce the risk of further myocardial infarction (MI), was variable. As part of a global effort to reduce mortality from STEMI in smaller healthcare institutions, without a cardiac catheterization laboratory, New Zealand endorses several international guidelines for STEMI management, with expert-led biennial review.[2 3] However, in our hospital there was no recently updated guideline to aid junior doctors in identifying, investigating and managing patients with STEMI and triggering a co-ordinated senior clinician response.

A significant problem identified was the absence of registrar level doctors, who do not complete training placements at our rural institution. Patients with chest pain arriving by ambulance and who fit the criteria for suspected acute coronary syndrome (ACS) bypass the emergency department (ED) and go straight to the coronary care unit (CCU) for review by the on-call house

officer. Frequently, this first assessment of a probable ACS patient and interpretation of electrocardiogram (ECG) investigations can be by a newly qualified doctor. Consequently, it is important that updated trust guidelines exist to guide accurate STEMI recognition and management.

On further inspection, we felt that there were a number of factors that contributed to suboptimal implementation of STEMI guidelines.[1] One was the need for refreshed awareness amongst nurses and junior doctors that rapid reperfusion therapy is recommended within 30 minutes of arrival. Furthermore, the co-ordination of initial nursing triage to subsequent junior doctor and consultant assessments of the STEMI patient was inconsistent. Contributing factors to this phenomenon include the need for an updated and easily accessible local trust STEMI protocol and the fact that initiation of reperfusion therapy overnight requires senior clearance. In the absence of on-site registrars, decision to thrombolyse is the responsibility of the on-call physician, who may be at home outside normal working hours. Uncertainty existed amongst junior doctors regarding the necessary out-of-hours escalation pathways to trigger senior support and send electronic ECG traces to on-call physicians overnight for review prior to thrombolysis. Consultant travel time from home to hospital was often between 15-20 minutes and without swift initiation of the thrombolysis pathway, treatments were frequently delayed and door-to-needle time occurred outside guideline recommendations.

BACKGROUND

Our hospital is a rural 131-bed district general hospital, serving a population of approximately 65,000 residents over a geographical distribution of 14,000 square kilometres.[4 5] Our furthest referring catchment town is 200 kilometres away and currently ambulance crews are not trained in out of hospital thrombolysis administration as the paramedic workforce is predominately comprised of volunteers. Population demographics for the region show that our health board has an ageing population, with 21% of residents over the age of 65 years old.[4] In addition, 89% of the population consists of residents with white, Caucasian heritage and ethnic minorities comprising 11%. 15% of residents over 15 years old are regular, daily smokers.[4]

Our quality improvement team is made up of 2 resident medical officers (fourth year junior doctors), 1 CCU nurse and 1 senior ward pharmacist.

ACS is a common condition with a major global impact on healthcare resources and expenditure.[6] Most cases of ACS are caused by coronary artery plaque rupture and thrombus formation. When thrombosis leads to total occlusion of blood flow within an epicardial artery, acute STEMI is often the clinical outcome. STEMI is a clinical syndrome defined by characteristic symptoms of myocardial ischaemia in association with persistent ECG ST elevation and raised biochemical markers of myocardial necrosis. Effective management requires prompt recognition, triage, and reperfusion. To aid in assessment and diagnosis an ECG should be performed < 10 minutes after presentation with immediate clinician review if there is a high suspicion of STEMI.[1]

ACS continues to be a serious public health problem in industrialized countries and is becoming an increasingly significant burden in the developing world. The World Health Organisation (WHO) informs that coronary artery disease (CAD) accounts for 7.2 million deaths/year, or 12% of all deaths worldwide.[7] Additionally, although CAD-related mortality rates worldwide have declined over the past four decades, it remains responsible for approximately one-third or more of all deaths in individuals over age 35.[8] At present, STEMI comprises 25% to 40% of acute MI presentations, with in-hospital and 1-year mortality rates at 5%-6% and 7%-18% respectively.[9 10] Despite developments in management and education on cardiac risk behaviours, MI remains a serious health burden on society.

Influencing our study is the finding that a major independent predictor of early death from STEMI is time to reperfusion.[11] The fundamental approach to the management of STEMI in New Zealand includes early recognition, appropriate and timely delivery of reperfusion therapy and implementation of secondary prevention recommendations.[1] International guidelines are clear in specifying that patients with acute STEMI should receive coronary reperfusion therapy with either primary percutaneous coronary intervention (PCI) or thrombolysis.[2 3] Shorter time to reperfusion is associated with better survival for STEMI patients, whether they receive thrombolysis or PCI.[1] Furthermore, regional medical systems and protocols should seek to enable rapid recognition and timely reperfusion of STEMI patients. Depending on the available in-hospital facilities, the goal for patients with STEMI should be to achieve a door-to-needle time within 30 minutes (for thrombolysis) and a door-to-balloon time within 90 minutes (for PCI).[12] On inference from a range of randomised clinical trials, timely PCI has become the optimal strategy for the treatment of STEMI. For example, primary PCI can achieve Thrombolysis in Myocardial Infarction (TIMI)-3 flow in the infarct artery in >90% of patients and has a clear advantage over fibrinolytic therapy, which can achieve TIMI-3 flow in only 54%.[13] However, thrombolysis should be used if timely PCI is not available, and is capable of re-establishing antegrade blood flow in nearly 75% of patients when administered within 30 minutes of presentation.[14] This is certainly appropriate for non-PCI capable hospitals such as ours, where access to a cardiac catheterisation lab is over 2 hours drive away.

System delays to reperfusion are correlated with higher rates of mortality and morbidity.[15 16] Successful delivery of the American College of Cardiology (ACC)

Guidelines in the management of STEMI is associated with a 2.9% in-hospital mortality for < 30 minutes compared with 4.1% for 31-45 minutes and 6.2% for > 45 minutes.[17] Furthermore, the Cooperative Cardiovascular Project 30-day mortality significantly increased from 12.5% for those treated within 30 minutes, to 14.1% for those treated 31-90 minutes and 19.9% for those treated after 90 minutes.[18] Issues with poor adherence to the ACC guidelines have been identified by McNamara et al.[17] who found that only 46% of patients were treated within 30 minutes. Previous BMJ quality improvement projects have demonstrated reducing door-to-balloon time for acute STEMI in PCI-capable centres but none appear to address reducing door-to-needle time in a non-PCI-capable hospital.[19] What is consistent throughout these projects however, is the awareness that successfully implementing early reperfusion therapy is a challenging and complex task that requires a multi-faceted approach with consistent engagement from local stakeholders.

For patients presenting to a non-PCI-capable hospital, timely delivery of fibrinolytic therapy relies on assessment of [1]:

1. Time from onset of symptoms
2. ECG changes consistent with STEMI
3. Risk of complications related to STEMI
4. Risk of bleeding with fibrinolysis
5. Presence of shock or severe HF
6. Time required for transfer to a PCI-capable hospital

Unfortunately, 27% of patients in New Zealand who are eligible for reperfusion therapy fail to receive it.[1] Therefore, reliable, timely delivery of thrombolysis demands greater awareness, faster recognition and more effective collaboration between clinicians and nurses involved in the initial assessment of STEMI patients. As a life threatening condition associated with time-dependent, therapy-related morbidity and mortality rates, quality care of STEMI patients is paramount. Due to our concerns regarding the assessment and management of STEMI patients previously identified, we were inspired to conduct a quality care review with the aim of highlighting the local STEMI protocol and the mechanisms for escalating care, to promote more timely management and positive patient outcomes.

BASELINE MEASUREMENT

Our SMART aim for this project is to improve the percentage of patients receiving thrombolysis therapy in less than or equal to 30 minutes, from 40% to 80% within a 12 month period. This clinical target comes after consideration and adoption of the British Heart Foundation's recommendation that door-to-needle times of 30 minutes are achievable in 80% of patients in rural communities.[20] To achieve our project goals and review quality improvement progress, we utilised international guidelines to form a gold-standard thrombolysis management framework and collected data at 6 monthly intervals over a 12 month period (i.e. 3 data collection points - baseline, post intervention 1 and post-intervention 2). We commenced the project with our baseline measurement and describe our data collection model below. This format was replicated for both post-intervention 1 and 2 data collections.

Baseline data was retrospectively collected, from patient files, over a six-month period for all hospitalised adult (over 18-years old) patients with a confirmed diagnosis of STEMI. Case notes were obtained via the medical records department using a list of coded diagnoses that included STEMI, acute transmural myocardial infarction and acute myocardial infarction. 37 sets of notes were analysed to identify patients that satisfied STEMI criteria as defined by the European Society of Cardiology/ACCF/AHA/World Heart Federation Task Force for the Universal Definition of Myocardial Infarction guidelines as shown below:[21]

1. New ST elevation at the J point in at least 2 contiguous leads of ≥2 mm (0.2 mV) in men or ≥1.5 mm (0.15 mV) in women in leads V2-V3and/or of ≥1 mm (0.1 mV) in other contiguous chest leads or the limb leads.
2. New or presumed new LBBB
3. Isolated posterior MI - tall R wave and ST depression in V1-V2

Localisation of the infarction territory was then determined using the following criteria:

1. Septal: V1 and V2
2. Anterior: V3 and V4
3. Lateral: V5 and V6
4. Anteroseptal: V1-V4
5. Anterolateral: V3-V6
6. Extensive anterior: V1-V6
7. Inferior: II, III, aVF
8. High Lateral: I, aVL
9. Posterior: tall R wave and ST depression in V1-V2

Documented evidence of thrombolysis administration, including time given, was then confirmed by reviewing inpatient medication charts. Those who met the criteria for STEMI were included in the data collection. Patients with non-ST elevation myocardial infarction (NSTEMI) and unstable angina were excluded. Our primary outcome measure was administration of fibrinolytic therapy within 30 minutes of hospital arrival. This was defined as the time interval between arrival to CCU and eventual thrombolysis. Secondary outcome measures focused on fulfilling the remaining ACC guidelines [6] for STEMI management that included administration of anticoagulant therapy (Enoxaparin) and antiplatelet agents (Aspirin and Clopidogrel/Ticagrelor). Furthermore, we collected data regarding time taken from initial nursing triage to first doctor assessment, time between first doctor assessment and eventual thrombolysis, initiation of secondary prevention medications (Beta-blocker, ACE inhibitor (ACEi) and statin) and all-cause in-hospital mortality. Clinical information was transcribed onto a pre-designed data collection

proforma and analysed on a secure electronic spreadsheet program.

For baseline measurement collection, 37 sets of notes were identified and 7 patients were excluded due to diagnosis of NSTEMI. A total of 30 patients (20 males, 10 females) were included in the baseline measurement. 17 out of 30 patients (57%) failed to achieve fibrinolytic administration within 30 minutes of arrival to CCU. 13 out of 30 patients (43%) satisfied ACC guidelines with door-to-needle time < 30 minutes. Total door-to-needle time in STEMI patients (n=30) averaged 37.3 minutes (SD = 22.4 minutes), with fastest time 15 minutes and slowest time 105 minutes (range 15-105 minutes). After initial triage by nursing staff, the mean waiting time to first doctor assessment was 13.5 minutes (SD = 15.7 minutes), with range 0-70 minutes. Once the patient had been reviewed by a doctor and high suspicion for diagnosis of STEMI acknowledged, the mean waiting time to thrombolysis was 23.2 minutes (SD = 18 minutes) with range 5-90 minutes. The mean number of medications prescribed to each patient from a list of Enoxaparin, Clopidogrel/Ticagrelor, Aspirin, Nitrates, ACEi, Beta-blocker and Statin was 5.04. Additionally, five patients died whilst in hospital (17%). When analysing results, we regarded $p<0.05$ as statistically significant.

DESIGN

When considering the underlying causes of the problem, it became apparent that a multi-faceted set of interventions were necessary to improve the management of STEMI in our hospital. Firstly, we located a recently updated local STEMI protocol. Our audit aimed to review the efficacy of this new protocol in the workplace and assess its suitability for inclusion in permanent trust guidelines. Secondly, since there was a lack of awareness of the new STEMI protocol, we promoted an early STEMI recognition and treatment algorithm, based on the updated guidelines. This was reproduced in check-list and poster format for display in key clinical areas, for example, CCU and doctors' offices. The algorithm was intended to act as an instructional visual aid for staff to implement appropriate STEMI management within 30 minutes. Furthermore, it provided definitive instructions for junior doctors assessing STEMI patients, guiding thrombolysis suitability and triggering senior physician involvement.

Next we engaged key stakeholders to develop awareness of the implications of poor STEMI management and assimilate potential quality improvement strategies. This was achieved through oral presentations and informal discussion with both medical and nursing staff over a three-week period. We presented the updated STEMI protocol, highlighting the importance of time critical interventions. Data from our baseline measurement was used as a rationale for adopting these modifications to practice, thereby attempting to foster a fundamental culture change from hospital staff. These sessions focused on the recognition, investigation, and management of STEMI patients and the importance of early fibrinolytic therapy in improving patient outcomes and reducing mortality. Educational sessions included ECG teaching on the recognition of STEMI and associated infarction territories. This aimed to improve the diagnostic confidence of junior doctors and in turn reduce door-to-needle times.

Finally, we demonstrated how to use the available electronic system that facilitates off-site ECG interpretation, via data sharing with encrypted tablet devices. This system supports the newly updated STEMI protocol as if a junior doctor suspects a diagnosis of STEMI, ECGs can be sent directly to the on-call consultant's tablet. Verbal instructions to prepare for fibrinolytic therapy, provided no contra-indications exist, can then be initiated, in turn reducing door-to-needle times. The same system can also be used by juniors if there is any clinical uncertainty surrounding the diagnosis, supporting accurate STEMI recognition.

We have noted from previous quality improvement project experiences that sustainability of clinical interventions is challenging. This is often due to the high turn-over of staff, especially junior doctors, who frequently rotate through different jobs in different hospitals. We were keen to ensure the longevity of improvements made in our hospital. Therefore, we recruited junior doctors, who we recognised would be based in the hospital for a minimum of two years, to the STEMI-management quality improvement team. This was to ensure that the momentum of the project was sustained. Recruitment of future members to the team will follow a similar practice to encourage continuing progress.

STRATEGY

Strategy Meeting 1: Meetings were held by the STEMI-management quality improvement team to review the updated STEMI guideline and evaluate how best to implement it within our hospital. Our aim was to identify how the guideline could be easily accessed by service users to guide the diagnostic, therapeutic and care escalation steps required in the management of STEMI patients. Focus was on accessibility and usability for all relevant staff members.

PDSA cycle 1: A recognised aim from our strategy meeting was to raise awareness of STEMI diagnostic criteria and integrate the updated local protocol within our hospital. We hypothesised that streamlining the STEMI protocol would improve its user friendliness. Therefore, we simplified the guideline to a recognition and management flow diagram. This was reproduced in poster format and displayed in CCU and doctors' offices. To assess suitability of our poster, a first draft was critically analysed by CCU staff, who then completed an evaluation questionnaire. The poster received positive feedback with many commenting that it was easy to

understand and clearly highlighted how to acquire senior support. Further points included the design was bold, colourful and easy-to-read.

PDSA cycle 2: After consideration of the evaluation questionnaire responses, minor layout adjustments were made to the flow diagram poster and it was more widely displayed on inpatient wards. The STEMI guideline was integrated into hospital practice and 6 months was allocated for staff familiarisation with this intervention before further data collection on door-to-needle times occurred. The objective was to assess whether a more accessible, simplified flow diagram could change mean times to thrombolysis of STEMI patients in our hospital.

Staff Education Workshop 1: Questionnaire data suggested that staff would be receptive to educational workshops to compliment introduction of the new STEMI guideline. Although this was not a PDSA cycle, we felt this was a good opportunity to highlight the components of the new protocol and refresh understanding on the management of ACS. The workshop would aim to encourage staff to manage STEMI patients with the new guideline and feel confident in its application to clinical practice. Consequently, we held an educational STEMI awareness workshop aimed at CCU staff and junior doctors. The session focused on the early recognition and management of STEMI and was designed to emphasise the importance of confident ECG interpretation and timely thrombolysis to improve patient outcomes. 60% of CCU staff and 50% of junior doctors attended the session. We hypothesised that face-to-face teaching would have a greater impact on staff learning than self-directed tuition from posters only. To further engage staff we decided to utilise examples of real-life clinical scenarios and ECGs to give authentic representations of STEMI patients and help individuals to contextualize background theory into clinical practice. Furthermore, group discussion regarding a recent clinical case, identified during the baseline data collection with significantly delayed door-to-needle time, was encouraged to explore potential improvements in management. Feedback from the session demonstrated that, in particular, junior doctors found the workshop useful. Therefore, it was repeated during protected junior doctor teaching time to gain greater attendance (90% of junior doctors). To address potential queries relating to the introduction of the new STEMI protocol, we appointed 'guideline mentors' to support service users. They were familiar with the details of the guideline and ensured that STEMI education could be continued and reinforced on a day-to-day basis.

PDSA cycle 3: After analysis of the data collected from PDSA cycle 2, further improvements could still be made. It was clear from the baseline data that thrombolysis of STEMI patients within 30 minutes is dependent on rapid response and definitive decision-making from junior and senior doctors. When exploring the reasons for inadequate door-to-needle times, we noted clear delays between initial triage times by CCU nurses and subsequent medical assessments by both junior doctors and consultant physicians. This needed to be explored further and it became apparent that solving the problem was more complex than just promoting educational development and designing a flow diagram. Therefore, we sought advice from CCU staff on how to streamline the escalation pathway and improve response times. After discussion with cardiac nurses, we introduced a target time for first doctor assessment of the 'cardiac triage' patient of < 5 minutes. Furthermore, if the assessing CCU nurse or junior doctor recognised a diagnosis of STEMI then an escalation pathway was initiated with a direct page to the on-call consultant physician made via switchboard. This system operated in conjunction with a target time of < 20 minutes for thrombolytic therapy administration after first doctor assessment. We introduced laminated copies of the escalation protocol to be displayed on CCU and also had lanyard sized copies printed and distributed to the house officers. Feedback was positive, remarking that the pathway made staff feel more confident and comfortable in contacting the consultants early in patient assessment. Data was collected on average time to 1st doctor review and mean waiting time to secondary senior clinician response. It was hypothesised that introducing a care escalation protocol associated with target assessment times by the junior and senior clinicians would improve overall door-to-needle times.

PDSA cycle 4: Associated with identified delays between initial triage times by CCU nurses and subsequent medical assessments by both junior doctors and consultant physicians, CCU staff also commented that management of STEMI patients at night was a concern. After reviewing our baseline and post-intervention 1 data set, we identified a higher mean waiting time for senior clinician review during night shifts. This was hypothesised to be related to the consultant on-call being off-site overnight and the subsequent delay between being made aware of a new cardiac patient and travel to hospital. We aimed to address this issue and improve overall door-to-needle times by promoting an out-of-hours remote electronic ECG interpretation system. To assess our progress towards our initial SMART aim, further data collection on door-to-needle times occurred after 6 months and overall hospital performance assessed.

Staff Education Workshop 2: After discussion with colleagues, it became apparent that there was a lack of awareness regarding the use of the remote electronic ECG interpretation system, which allows off-site consultants to review patient ECGs on an encrypted tablet. Verbal orders from consultants to prepare for thrombolysis administration on their arrival could then be initiated, streamlining the process. Therefore, we implemented training to allow staff to familiarise themselves with this system and encourage its use out-of-hours. Competency with using the remote electronic ECG interpretation system was confirmed with an observed

demonstration before initiating further data collection on door-to-needle times.

PDSA cycle 5: To ensure appropriate prescribing of ACS medications and secondary prevention, ward pharmacists conducted regular medication chart reviews and liaised with the ward team to maximise STEMI management. A checklist of ACS therapy was also included in the updated protocol. Medication charts were reviewed and data collected on number of ACS treatments prescribed for each patient from the checklist.

Our hope was that collectively the quality improvement project would evidence progress. Following PDSA cycle 4, post-intervention 2 data demonstrated further improvements in the implementation of the STEMI protocol. These results are due to be presented at a hospital grand round meeting to reinforce continued positive change to clinical management of STEMI patients. Furthermore, increased utilisation of the remote electronic ECG review system has been observed, with staff recognising improved communication between on-site and off-site team members and coordination of thrombolysis initiation. It is hoped that the longevity of this project will be maintained by ensuring training on STEMI management is conducted with each junior doctor rotation by 'guideline mentors'. A run chart was created retrospectively to observe for any changes over time.

RESULTS

6 months post-baseline measurement (Post-intervention 1):

30 sets of notes were identified and 5 patients were excluded due to alternative diagnoses. A total of 25 patients (12 males, 13 females) were included in the first post-intervention data collection. 9 out of 25 patients (36%) failed to achieve fibrinolytic administration within 30 minutes of arrival to CCU. 16 out of 25 patients (64%) satisfied ACC guidelines with door-to-needle time < 30 minutes. Total door-to-needle time in STEMI patients (n=25) averaged 32.36 minutes (SD = 18.1 minutes), with fastest time 10 minutes and slowest time 90 minutes (range 10-90). After initial triage by nursing staff, the mean waiting time to junior doctor review was 5.89 minutes (SD = 7.08 minutes), with range 0-30 minutes. Pleasingly, after CCU nurse review, 72% of cardiac triage patients received a first doctor assessment in < 5 minutes. Once the patient had been reviewed by a junior doctor and high suspicion for diagnosis of STEMI acknowledged, the mean waiting time to thrombolysis was 25.25 minutes (SD = 15.87 minutes) with range 10-68 minutes. 52% had thrombolytic therapy administered in < 20 minutes after 1st doctor assessment. The mean number of medications prescribed to each patient from a list of Enoxaparin, Clopidogrel/Ticagrelor, Aspirin, Nitrates, ACEi, Beta-blocker and Statin was 4.25. Additionally, two patients died whilst in hospital (8%) with complications of cardiac arrest and cardiogenic shock documented.

12 months post-baseline measurement (Post-intervention 2):

26 sets of notes were identified and 3 patients were excluded due to diagnosis of NSTEMI. A total of 23 patients (13 males, 10 females) were included in the second post-intervention data collection. 6 out of 23 patients (26%) failed to achieve fibrinolytic administration within 30 minutes of arrival to CCU. 17 out of 23 patients (74%) satisfied ACC guidelines with door-to-needle time < 30 minutes. Total door-to-needle time in STEMI patients (n=23) averaged 30.96 minutes (SD = 18.1 minutes), with fastest time 15 minutes and slowest time 77 minutes (range 10-77). After initial triage by nursing staff, the mean waiting time to junior doctor review was 6.87 minutes (SD = 8.21 minutes), with range 0-35 minutes. Despite an increased average waiting time for first clinician response, 70% of cardiac triage patients still received a doctor assessment within < 5 minutes of triage. Once the patient had been reviewed by a junior doctor and high suspicion for diagnosis of STEMI acknowledged, the mean waiting time to thrombolysis was 24 minutes (SD = 14.9 minutes) with range 10-76 minutes. 65% had thrombolytic therapy administered in < 20 minutes after first doctor assessment. The mean number of medications prescribed to each patient from a list of Enoxaparin, Clopidogrel/Ticagrelor, Aspirin, Nitrates, ACEi, Beta-blocker and Statin was 5.96. Additionally, two patients died whilst in hospital (8.7%) with complications recorded as cardiogenic shock.

Overall, we saw a statistically significant relationship between the implementation of the ACC guidelines for thrombolysis in STEMI patients and door-to-needle times (Table 1.0), with 74% of patients receiving fibrinolytic therapy in < 30 minutes of arrival to hospital compared to 43% at baseline. Certainly, pre-intervention baseline measurements on management of STEMI patients were significant and suggested a strong correlation between failure to achieve door-to-needle times of < 30 minutes and absence of regular staff training and an updated treatment protocol ($p<0.05$). Pleasingly, we have also observed a significant relationship between higher numbers of patients thrombolysed within 30 minutes and the introduction of a simplified treatment algorithm and overnight ECG review service ($p<0.05$).

We have observed greater awareness of the importance of rapid assessment, investigation and management of the STEMI patient amongst junior colleagues (Figure 1.0). 70% of house officers conducted a provisional patient assessment in < 5 minutes of initial CCU nursing triage, compared to 43% at baseline. Pleasingly, it appears that the increased awareness and utilisation of the remote electronic ECG interpretation system has contributed to improving overall door-to-needle times. Target times (< 20 minutes) for thrombolysis administration after first doctor assessment have been better achieved, 65% compared to 43%. Additionally, on further inspection of the data, more patients attending out-of-hours are successfully treated within 30 minutes from arrival. Specifically, this appears to be directly correlated to a more efficient process of escalating care to

the senior clinician and more rapid analysis of abnormal ECG traces. Since recruiting pharmacy advocates to review medication charts, the number of cardiac medications prescribed on admission has increased with an average of 5.96 medications compared to 4.25.

We have noted improving in-hospital mortality since the start of our project, 17% to 8%, and it is certainly possible that implementation of our quality improvement interventions has contributed to better patient outcomes by reducing door-to-needle times. However, we acknowledge that this may reflect the fact that our PDSA cycles were completed with a patient cohort who had fewer cardiac risk factors and co-morbidities when compared to the baseline group. Additionally, those patients that did die suffered cardiac complications that carry a poor prognosis irrespective of the door-to-needle time. We also appreciate that we cannot state that our project was the sole contributor to changing in-hospital mortality and it may have occurred due to a combination of factors or indeed pure chance. Therefore, to further evaluate these trends we will need to initiate additional PDSA cycles and compare future data to evaluate sustained quality improvement over time.

Applying the three probability-based rules to the run chart (Figure 2.0) can evidence non-random patterns in the data [22]. For example, there are six or more points all below the baseline median during PDSA 1+2 and PDSA 3+4, suggesting that these results are not due to chance alone and are statistically significant. This is supported by a calculated p-value of <0.05. Furthermore, data points are clearly crossing the median line in runs, where a series of points in a row are on one side. This suggests that the quality improvement interventions are successfully keeping door-to-needle times towards the target of 30 minutes. Finally, towards the end of the project during PDSA 3+4, we can see a clear trend where five consecutive points are all going down. Extrapolating these findings further, it seems reasonable to conclude that sustained improvement in STEMI management has been observed with each PDSA cycle. However, there are perceived anomalies where the average door-to-needle times varied wildly. This is confirmed by the time ranges and statistical dispersion calculated for the baseline and post-intervention data sets. Postulating causation of this phenomenon has revealed that it may be due to patients developing significant cardiac symptoms after presentation to hospital and changing pathological ECG traces requiring that thrombolysis either be delayed or initiated later in the assessment. To note, all patients included in the audit did not have any absolute contraindications to thrombolysis (See supplementary - Baseline and Postintervention 1 and 2 STEMI data).

LESSONS AND LIMITATIONS

We have learnt a number of important lessons during this project, none more so than the importance of a multi-faceted approach to tackling an important clinical problem. Certainly there is no perfect strategy to improving the management of STEMI within busy clinical environments. It requires a co-ordinated effort from a dedicated team of multi-disciplinary members to instigate change, and even then, progress may prove to be unpredictable. However, small interventions can lead to improvements in practice, and this project highlights the need for healthcare professionals to be continually motivated to achieve quality improvements.

Another key lesson is that a singular approach does not necessarily work in all situations and therefore, flexibility is vital to achieving success. For example, we focussed our initial interventional design on STEMI education and clinical guideline awareness. However, it became clear that a significant barrier to achieving widespread reduction in door-to-needle times was clinician availability. Therefore, familiarisation of remote electronic systems was required to support timely STEMI patient management. This required collaboration with departmental staff to ensure its success. As a group, we have learnt to continually adapt interventional design to address unexpected problems in the clinical process and seek service-user input when making changes to quality improvement strategies.

Admittedly there are a number of limitations to this project. A key limitation of this study is the relatively small population size studied. However, this potentially reflects the incidence of STEMI at our rural institution, which serves a modest community of 65,000 people. For comparison, the next geographically closest health board has a tertiary centre and serves 510,000 patients. Furthermore, 15,000 ACS patients per year are admitted to New Zealand hospitals, with 20% (3000) diagnosed as STEMI.[23] Consequently, we might expect that in a rural hospital of this size that the cohort numbers in the baseline and post-intervention groups are a fair representation of the relatively small overall population. It is hoped that further quality improvement projects on this topic will be conducted over a longer time period to analyse a larger patient cohort and improve the validity of the study.

Whilst our statistical analysis provides significant P-values and sustained improvement in STEMI management has been observed with each PDSA cycle based on a run chart of consecutive patients, we recognise the limitations of our data set. Although we show positive outcomes of our quality improvement measures overall, we are cautious to generalise our findings and recognise that our results should be interpreted with caution in relation to settings other than that in which they were originally tested. As previously discussed, our centre is a unique setting and our health demographics are not necessarily representative of other geographical areas. In addition, our study results could have been affected by bias and confounding factors. For example, time to hospital presentation from symptom onset, which could affect ECG findings and accurate recognition of STEMI.

Since project completion we have also considered the varying clinical experience of the junior doctor assessing the patient, which in our hospital can range from 1st to 4th year post-graduation. This may confound the results for door-to-needle times as it is possible that more experienced doctors demonstrate more confident ECG interpretation and initiation of STEMI management.

Physical data collection was conducted at 6 monthly intervals but recordings of door-to-needle times for each month were documented retrospectively. We recognise that more frequent data collection could provide a greater depth of information, in particular, relating to the impact of our interventions on door-to-needle times. It would also strengthen the quality improvement project to have a more detailed understanding of which interventions had greater impact on positive outcomes. We appreciate this could be achievable with regular review of smaller-scale test interventions than we used and promotion of only the more positive intervention to service users. However, we did not have access to sufficient resources to conduct our project to this degree. In addition, we recognised that data collection at shorter time periods would have greatly reduced the numbers of patients studied, due to the relatively small population our centre services, and reduced the power of our study. Therefore, we elected to collect data at 6 monthly intervals. Furthermore, limiting data collection to 6 monthly intervals helped to minimize the Hawthorne effect. The Hawthorne effect is a phenomenon whereby staff may artificially change their behaviour during a study due to the awareness that it is under review.[24] Although, this is hard to assess and may still have occurred during our data collection periods, It is possible that if we had conducted more frequent data collection that the Hawthorne effect may have been exaggerated, affecting our results.

This study was only conducted over a twelve-month period, and as such its sustainability is, as yet, untested. Therefore, the key challenge is to ensure future sustainability. We accept that use of a multi-disciplinary quality improvement team structure (doctors, nurse and pharmacist) has strengthened the project through idea collaboration. However, whilst the team has been comprised of highly motivated individuals, it is a small team. Involvement of more members of the multidisciplinary team may bring new ideas to the group that have not previously been considered. In addition, greater quality improvement group inclusion may help to fuel positive work-based culture changes and promote the longevity of good practice within our hospital.

Finally, the lack of outcome measures in our data analysis is another limitation. We focused on achieving timely door-to-needle times and not the adequacy or effectiveness of thrombolysis. For example, we did not analyse complications secondary to thrombolysis, incidence of thrombolysis failure and subsequent rescue PCI, incidence of complications with MI, length of stay in hospital or post-discharge morbidity and mortality. By increasing study outcome measures, we hope to gain greater insight into the clinical demographics of STEMI patients to guide future practice.

CONCLUSION

As noted previously, STEMI is a serious condition with high morbidity and mortality if delays in reperfusion therapy occur. On review of the literature it appears that non-PCI capable centres have varying success at reaching target door-to-needle times. Our baseline results, 43% patients thrombolysed in < 30 minutes, are comparable to previous studies (46%).[25] Additionally, other studies have found a relative decrease in door-to-needle times after intervention, with 67% of patients receiving timely thrombolysis within 30 minutes of hospital arrival, which is consistent with our post-intervention results of 74%.[26] For many years the international community has been vigorous in promoting internationally recognised pathways to improve the management of STEMI and modify patient outcomes. However, translating recommendations into practice is a challenging and complex task that requires a multi-faceted approach with sustained engagement from local stakeholders. We have implemented a number of simple but effective interventions that have improved the utilisation of the local STEMI protocol in our hospital. However, whilst changes to STEMI management in our hospital have been noted, it is recognised that ongoing quality improvement is required. A key challenge remains to ensure that momentum of this project continues and forms a platform for sustainable clinical improvement in the long term. To address this we propose expanding our data set by studying a larger cohort of patients over a longer time period, promoting regular training opportunities for hospital staff on the management of STEMI and presenting the project to a wider audience of stakeholders.

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Declaration of interests Nothing to declare

Ethical approval Local policy did not require ethical approval to be sought for this project

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