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Safety and feasibility of patient transfer by helicopter for primary percutaneous coronary intervention

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Abstract

Aim Delayed treatment of patients undergoing transfer for primary percutaneous coronary intervention (PPCI) for ST-elevation myocardial infarction (STEMI) may reduce treatment benefits compared with fibrinolysis at the referring institution. We evaluated the feasibility of helicopter transfer of Whangarei patients to Auckland City Hospital for PPCI.

Method Clinical records of patients transferred from Whangarei to Auckland City Hospital by helicopter for PPCI were reviewed and clinical data reported.

Results Between May 2010 and August 2011, 24 patients (19 male, median age 63 years, range 41–79 years) underwent helicopter transfer PPCI from Whangarei. Overall, median time to reperfusion was 125 minutes (IQR 117–147 minutes). For the 9 patients presenting within working hours (weekdays 8am–5pm), the median reperfusion time was 122 minutes (IQR 105–136 minutes), compared with 134 minutes (IQR 117–159 minutes) in the 15 patients presenting outside working hours. One patient achieved reperfusion within 90 minutes from presentation while 8/24 achieved reperfusion within 120 minutes. All patients survived to hospital discharge, as did 23/24 at 30 day follow-up.

Conclusion Helicopter transfer for PPCI from Whangarei to Auckland City Hospital is a feasible treatment strategy for patients presenting with STEMI. Improvements in treatment times are required if the full benefits of this strategy are to be realised.

In the treatment of patients presenting with ST-elevation myocardial infarction (STEMI), the benefits of reperfusion therapy are well-recognised and time-dependent.[1] Primary percutaneous coronary intervention (PPCI) has been widely demonstrated to be superior to fibrinolysis as a reperfusion strategy in STEMI when a door-to-balloon (DTB) time of less than 90 minutes is achieved.[2–5]

Outside metropolitan settings in New Zealand, access to onsite primary angioplasty services does not exist so fibrinolysis has remained the only reperfusion strategy available to many patients presenting with STEMI. In more populous settings internationally, highly sophisticated regional systems employing urgent road transfer of STEMI patients to nearby angioplasty-capable facilities have been shown to be superior to onsite fibrinolysis.[6–9] Where greater distance precludes road transfer, this has been extended to successful helicopter transfer of small numbers of patients for PPCI with improving transfer times and a trend towards reduced mortality.[10–13]

Some evidence has suggested that excellent outcomes can be achieved with transfer for PPCI beyond traditional deadlines.[14] With the increasing utilisation of a transfer

strategy in PPCI and this supportive evidence, some guidelines allow a delay of up to 120 minutes from first medical contact to balloon time.[4] Nonetheless, concern remains that the potential benefits of early reperfusion may be lost due to unacceptable transfer delays in this setting.[15]

A rapid helicopter transfer pathway for PPCI was established between a neighbouring urban hospital and our PCI-capable facility in May 2010. We aimed to determine the feasibility of rapid helicopter transfer of STEMI patients for PPCI in our local context. The clinical characteristics, times to reperfusion and clinical outcomes of these patients are reported.

Method

A protocol for the rapid helicopter transfer of STEMI patients from Whangarei Hospital to Auckland City Hospital was developed and introduced in May 2010. Prior to this, no documented protocol existed for PPCI in STEMI patients presenting to Whangarei Hospital, so primary angioplasty was not routinely considered as a reperfusion strategy.

The referring hospital is a 223-bed, urban, secondary-level hospital. It services an urban population of approximately 48,000 patients and a large rural catchment area extending over 12,500km^2, including approximately a further 106,000 patients. The receiving hospital is a 1000-bed, urban, quaternary-level hospital with 24-hour PPCI capability. It serves a metropolitan population of 439,000 but is the only hospital in a city of 1.4 million people to provide a 24-hour PPCI service. It performs approximately 950 PCI procedures per year.

Helicopter transfer between the referring and receiving institutions requires a 132km flight, with duration of approximately 35 minutes. The only alternative transfer option between the 2 hospitals is a 165km road transfer by ambulance. Helicopter transfer was provided by a regional medical transfer service with 2 aircraft, both of which are Sikorsky S-76A helicopters. This service is based 3km from the referring hospital and was staffed and available by telephone contact 24 hours daily. The service provided by the carrier was not exclusive to this PPCI pathway or the referring hospital, providing all general helicopter medical transfer services in the region. Flights were staffed by 2 pilots and one advanced paramedic.

The clinical records of all patients undergoing helicopter transfer for PPCI between May 2010 and August 2011 were retrospectively reviewed. The records of all patients undergoing urgent transfer for coronary revascularisation were screened for inclusion. Where doubt existed as to the appropriateness of a patient's inclusion, this was adjudicated on by a senior author. The key determinant of inclusion was that the referring doctor's clinical impression was of STEMI. Patients who received fibrinolytic therapy at the referring institution and were subsequently transferred for rescue PCI were excluded from the analysis. In order to provide some context to clinical practice at the referring hospital, limited clinical information was retrospectively reviewed for STEMI patients undergoing fibrinolysis during the same period.

This clinical pathway was designed to test the feasibility of rapid transfer of a highly selected population and was not intended to define treatment arms for comparison between fibrinolysis and primary angioplasty. All patients presenting to the referring hospital with angina within 12 hours of symptom onset and with ST elevation of at least 1mm in 2 contiguous limb leads or 2mm in 2 contiguous precordial leads, a left bundle branch block or true posterior STEMI were considered eligible for the pathway.

Patients with inferior STEMI presenting within 3 hours of symptom onset were directed towards a fibrinolytic strategy but transfer for PPCI was available at the discretion of the referring physician. Once STEMI was diagnosed and provided there were no pre-defined contraindications to transfer, the referring Emergency Physician was prompted to make urgent contact with the transferring helicopter service to rapidly determine the feasibility of transfer.

Where the likelihood of significant delay in helicopter transfer existed, the referring clinician was directed to immediately administer fibrinolytic therapy (tenecteplase). The patient was then admitted to the referring hospital's inpatient facility with a view to early road transfer for coronary angiography within 48 hours. The option of immediate helicopter transfer for rescue PCI remained for those patients

with persistent angina or <50% resolution of ST segment elevation 1 hour after the administration of fibrinolysis. Where rapid transfer was feasible, the on-call interventional cardiologist at the receiving hospital was immediately contacted by a direct mobile telephone number and advised of the pending arrival of a STEMI patient. The receiving cardiologist then activated the usual cardiac catheterisation laboratory (CCL) PPCI protocol. The receiving cardiologist did not routinely review the ECGs of transferred patients until their arrival at the CCL.

The time of arrival at the referring hospital (door 1 time) was documented electronically by that hospital's emergency department and was made available for this analysis. All clinical notes from that hospital were reviewed including ECGs and medication records. The time of symptom onset was patient-reported as documented in the clinical record. In the case of patients who developed STEMI within the emergency department of the referring hospital (2 cases), the time of the first ECG documenting ST elevation was taken as the door time.

Flight logbooks and telephone records of the helicopter service provider were available to provide flight times and the time at which first contact was made by the referring clinician. Electronic records of all events in the CCL were reviewed to determine the time of arrival and the time of thrombus aspiration or balloon inflation, whichever occurred first. This time was defined as the balloon time. Normal working hours were defined as between 8am and 5pm Monday to Friday, excluding public holidays.

Nine time intervals of interest were defined and reported in each case: symptom onset to door 1 time, door 1 to ECG time, door 1 to helicopter contact time, helicopter contact time to departure time, door 1 to helicopter departure time, flight time, door 2 to arrival in the CCL, CCL arrival to balloon time and door 1 to balloon time. Patients were characterised by age, sex and high-risk features including anterior STEMI and the presence of cardiogenic shock (defined as systolic blood pressure <90mmHg unresponsive to fluid administration, requiring vasopressors).

Details of percutaneous intervention undertaken were available from CCL electronic records and angiographic cines were reviewed to determine the angiographic success of the procedure. Coronary flow before and after percutaneous intervention was defined according to the classification of the Thrombolysis in Myocardial Infarction (TIMI) trial.[16] Clinical outcome data was available from electronic records including the need for repeat intervention, cardiac surgery, 30-day major adverse cardiac events and mortality.

The primary endpoint was the proportion of patients with a DTB time of less than 120 minutes. Secondary endpoints included 30-day mortality and 30-day re-infarction, defined as recurrent chest pain associated with ST segment change or recurrent elevation of cardiac enzymes.

Results

Between May 2010 and August 2011, 24 patients presenting to the referring hospital with STEMI underwent urgent helicopter transfer for PPCI. In the same period, a total of 45 patients presented to the referring hospital with STEMI. Of these, 21 received fibrinolysis as the primary reperfusion strategy within the emergency department. Only 1 of these patients was considered for the rapid transfer STEMI protocol but did not undergo transfer due to anticipated transfer delays.

The reperfusion strategy was at the discretion of the admitting physician. As helicopter transfer for PPCI was an evolving strategy, it may not have been considered or thought feasible in a significant number of early cases. Three of the 21 patients receiving fibrinolysis subsequently required urgent transfer for rescue PCI. A further 13 patients received pre-hospital thrombolysis.

Table 1 summarises the characteristics of the patients undergoing transfer. The majority of patients (15/24, 63%) presented to the referring hospital by ambulance and ST elevation was demonstrated on a pre-hospital ECG in 10/24 (42%) of patients. Most patients (20/24, 83%) presented within 3 hours of symptom onset.

Table 1. Baseline characteristics

Characteristic (n=24)	Value
Age, median (IQR) (years)	63 (56–71)
Male, n (%)	19 (79)
NZ European, n (%)	19 (79)
Medical history, n (%)	
Hypertension	9 (38)
Diabetes	5 (21)
Dyslipidemia	7 (29)
Smoker	6 (25)
Known CAD	0
Previous angioplasty	0
Previous CABG	0
Clinical features, n (%)	
Cardiogenic shock	0
Anterior	14 (58)
Lateral	0
Inferior	10 (42)
Posterior	0
New LBBB	0
Presentation <3 hours of symptoms, n (%)	20 (83)
Presentation, n (%)	
Working hours	9 (38)
After hours	15 (62)
Pre-hospital STEMI ECG, n (%)	10/24 (42)

CAD = coronary artery disease, CABG = coronary artery bypass graft surgery, LBBB = left bundle branch block.

The overall median DTB time was 125 minutes (interquartile range 117–147 minutes). The distribution of these time intervals is demonstrated in figures 1a and 1b. For the 9 patients presenting within working hours, the median reperfusion time was 122 minutes (IQR 105–136 minutes), compared with 134 minutes (IQR 117–159 minutes) in the 15 patients presenting outside working hours.

The greatest delay was from triage to departure from the referring hospital. This interval was a mean time of 59 minutes and contributed a mean delay of 44% of the total DTB time. The time course of each patient, from presentation at the referring hospital to PPCI, is summarised in Figure 2.

The primary endpoint was achieved in 8/24 cases (33%) of whom one achieved a DTB time of less than 90 minutes. A further 8/24 (33%) cases were within 15 minutes of achieving a DTB time of 120 minutes. A DTB time of greater than 180 minutes was observed in 2/24 patients (8%). Both patients presented outside normal working hours. Other time intervals are summarised in Table 2.

Figure 1a. Distribution of door-to-balloon times - all patients

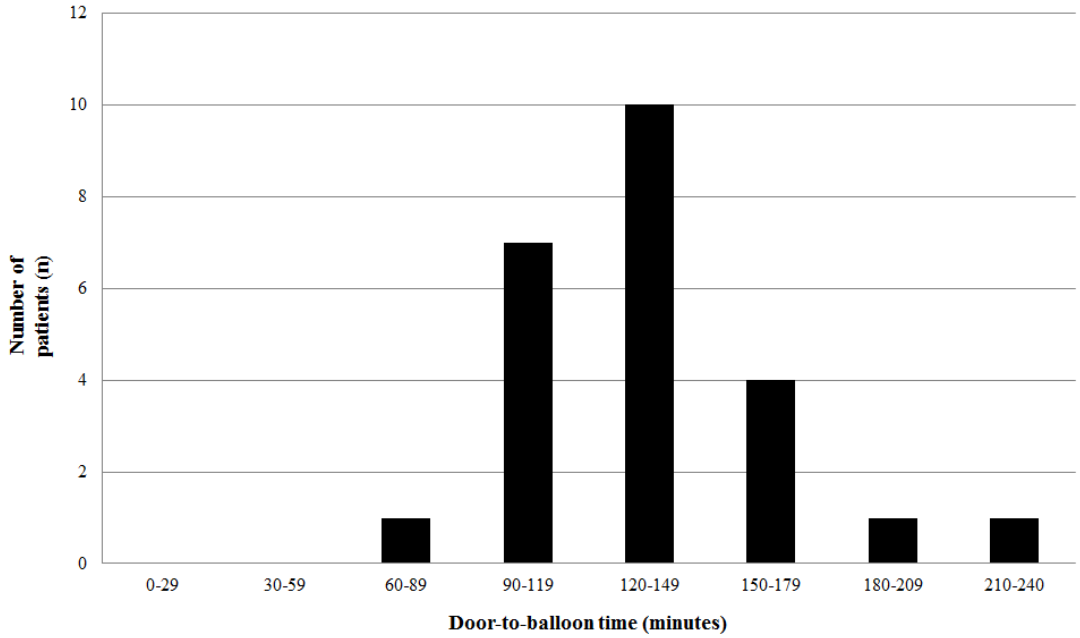

Figure 1b. Distribution of door-to-balloon times stratified by presentation time

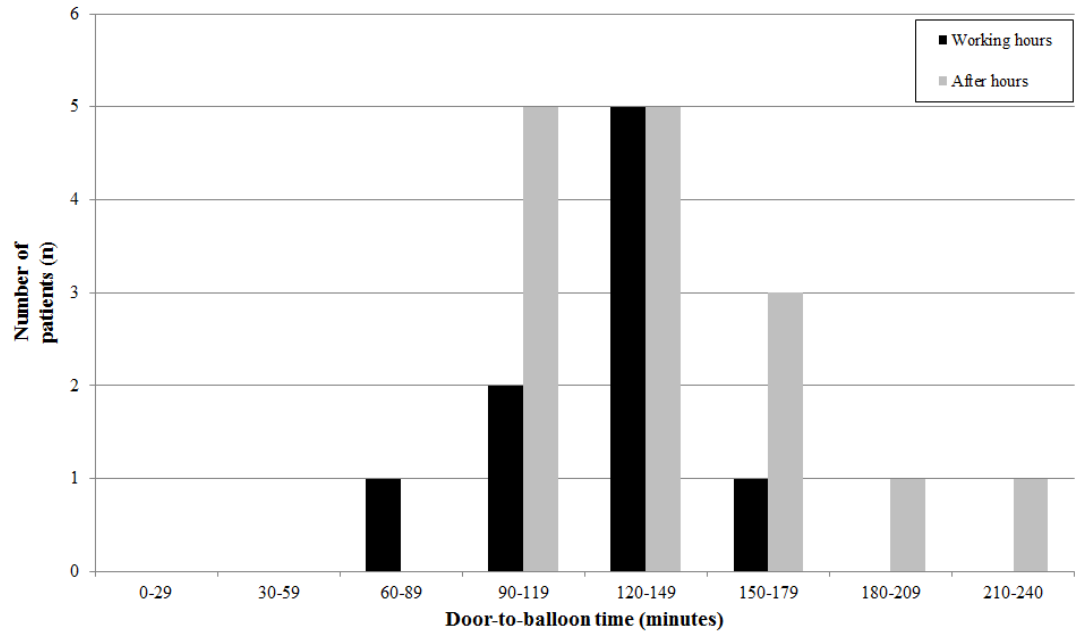

Figure 2. Distribution of important time intervals in transfer

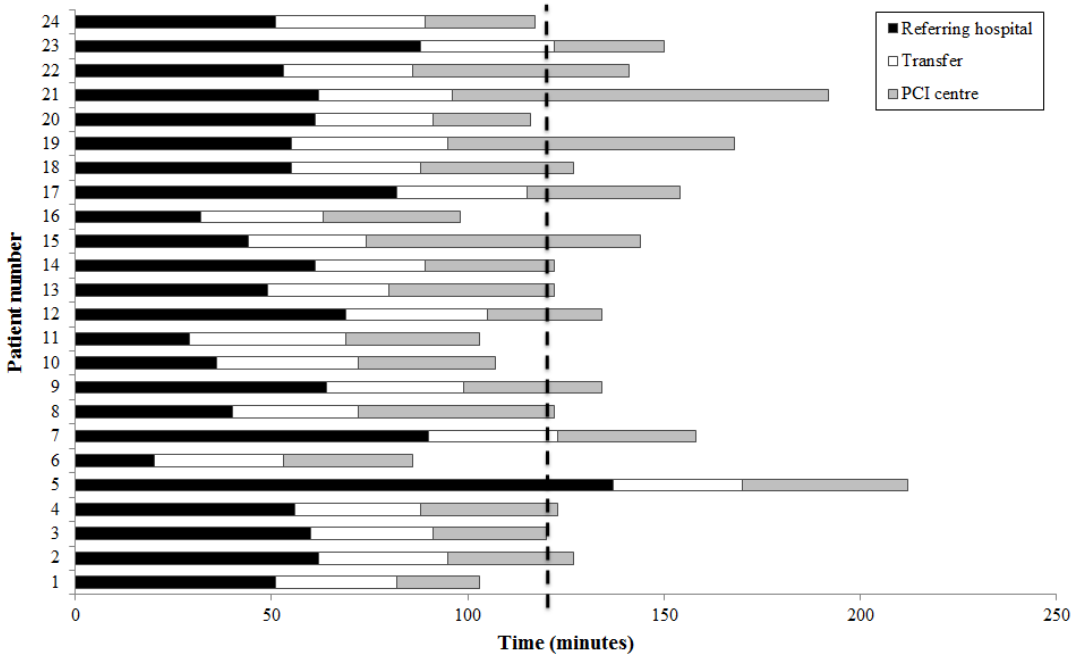

Table 2. Time intervals in transfer

Time interval, minutes (n=24)	Value
Referring hospital	
Symptom onset to door 1	97 (43–163)
Door 1 to ECG	5 (2–7)
ECG to contact helicopter	15 (9–19)
Contact helicopter to departure	35 (24–46)
Door 1 to departure	56 (47–63)
Transport times	
Transfer flight time	33 (31–35)
Door 1 to door 2	89 (77–98)
PCI centre	
Door 2 to CCL	17 (15–21)
CCL to balloon	19 (15–25)
Door 2 to balloon	35 (31–42)
Total door 1 to balloon	125 (117–147)
Working hours	122 (105–136)
After hours	134 (117–159)
Door 1 to balloon time <90 minutes, n (%)	1 (4)
Door 1 to balloon time <120 minutes, n (%)	8 (33)

Values are median (interquartile range).
CCL = cardiac catheterisation laboratory.

No patients required resuscitation or defibrillation during helicopter transfer. The CCL was falsely activated in 2/24 (8%) cases. In both cases, although the criteria for STEMI were not met, the patient was found to have significant obstructive disease and myocardial infarction (non-STEMI) and underwent PCI.

One patient with STEMI did not undergo PCI, rather undergoing thrombus aspiration in the setting of severe 3-vessel coronary disease, before proceeding to elective inpatient coronary bypass surgery.

Prior to intervention, 18/24 (66%) patients had TIMI grade 0-1 flow. Following intervention, normal (TIMI 3) coronary flow was established in 22/24 (92%) of the vessels undergoing intervention. The culprit artery was the left anterior descending artery in 14/24 (58%) cases. In all cases of intervention, only the culprit vessel was treated acutely. However, 3/23 (13%) patients undergoing PCI required staged PCI to a non-culprit lesion in another coronary artery at a later admission.

Drug-eluting stents were used in 14/23 (61%) of PCI cases. No patients required repeated percutaneous intervention during the STEMI admission although 2/23 (8%) of the patients who underwent PCI required non-emergent coronary bypass surgery during the same admission. Medical therapies offered to patients undergoing transfer are summarised in Table 3.

One patient required defibrillation for ventricular fibrillation during PPCI while another required insertion of a temporary pacing wire for complete heart block. No other major bleeding or procedure-related complications occurred.

All patients survived to hospital discharge, as did 23/24 (96%) at 30-day follow-up. One patient died from the complications of metastatic pancreatic carcinoma. The median length of hospital stay was 3 days. Six patients had a total hospital stay or 2 days or less. In-hospital and 30-day outcomes are shown in Table 4.

Table 3. Procedural characteristics

Characteristic (n=24)	
Culprit artery, n (%)	
Left anterior descending	14 (58)
Left circumflex	0
Right	10 (42)
Left main stem	0
Angiographic features, n (%)	
1VD	18 (75)
2VD	5 (21)
3VD	1 (4)
Left main stem	1 (4)
TIMI flow before PCI, n (%)	
0	11 (46)
1	7 (29)
2-3	6 (25)
TIMI flow after PCI, n (%)	
3	22 (92)
2	1 (4)
0-1	1 (4)
Bare metal stents, n	14
Drug-eluting stents, n	17
Stents per patient, median (range)	1 (0-3)
Medical treatment before PCI, n (%)	
Aspirin	24 (100)
Clopidogrel	20 (83)
Intravenous heparin	1 (4)
Low-molecular-weight heparin	17 (71)
Beta-blocker	1 (4)

VD = vessel disease, PCI = percutaneous coronary intervention, TIMI = thrombolysis in myocardial infarction flow grade.

Table 4. In-hospital outcomes and follow-up

Outcome	Value
Death in transfer, n (%)	0
In-hospital, n (%)	
Death	0
Reinfarction	0
Major bleeding	0
Length of hospital stay, median (IQR) (days)	3 (3–8)
PCI centre	2 (2–3)
Referring hospital	1 (0–2)
Repeat revascularisation procedure, n (%)	
Repeat PCI to culprit	0
Repeat PCI to non-culprit vessel	0
Emergent CABG	0
Elective CABG	3 (13)
Medications at discharge, n (%)	
Aspirin	24 (100)
Clopidogrel	20 (83)
Beta-blocker	20 (83)
Statin	24 (100)
ACEi	17 (71)
30-day, n (%)	
Death	1 (4)
Reinfarction	0

ACEi = angiotensin converting enzyme inhibitor

Discussion

This study demonstrates that emergency helicopter transfer is feasible in the treatment of STEMI patients undergoing PPCI in our region. It represents the first reported, rapid transfer protocol for cardiology patients of its kind in New Zealand.

Transfer times—The recent European Society guidelines target of <120 minutes was achieved in 8/24 (33%) patients. In patients failing to meet these evidence-based guidelines, the relative benefits of PPCI over fibrinolysis may be diminished, or harm done. It has been shown that where DTB time exceeds door-to-needle time by 60 minutes or more, the advantage of PPCI is lost.[17] However, much longer relative delays have been shown to deliver good outcomes in transfer settings and the longer 120 minute target has been proposed as one with some evidence for reduced mortality in such settings.[18]

Although our series was too small to demonstrate any statistically significant end points, the reperfusion times of patients presenting during working hours appeared similar to those presenting after hours, suggesting that delays would appear to be systematic rather than related to reduced services or staff.

A 30-minute target has been proposed for each of the 3 major intervals (door 1 to transfer, transfer time and door 2 to balloon) in transfer populations.[19] The greatest

delay in our series was at the referring hospital, demonstrating that rapid pathway activation is imperative.

Indecision in this phase of patient care or delay in helicopter dispatch have the potential to lead to unacceptable transfer times and worse clinical outcomes. Although marginally outside this proposed goal, the obligatory transport time of up to 40 minutes in our cohort does apply significant pressure on the overall DTB time.

Although treatment times are longer than reported in international trials,[6-10] it is important to recognise the distinct geographic limitations of our local setting with air transport over longer distances than has typically been reported. It must also be recognised that most reports come from trial settings with highly sophisticated transfer networks.

The comparison of our population with available data from real-world settings compares much more favourably. In the National Registry of Myocardial Infarction,[18,20] 15% of 7133 patients undergoing transfer for PPCI met the recommended DTB time of 120 minutes or less while 4% achieved a time less than 90 minutes. Our median DTB time of 125 minutes compares favourably to the median time of 191 minutes reported in that registry.

Clinical outcomes—Despite transfer delays, in a patient population with relatively high risk features (14/24, 58% anterior MI), short term outcomes were good. Successful revascularisation was achieved in the majority of cases and no adverse cardiovascular outcomes were seen at short term follow-up. Despite transfer to the PCI centre and, in many cases, back to the referring hospital, patients received good evidence based medical therapies at discharge. Prior to PPCI, 83% of patients received a thienopyridine and 75% received heparin. This aspect of patient care could be better defined in clinical pathway documentation. The rate of inappropriate activation of the PPCI pathway (2/24, 8%) was low, and probably acceptable given that alternative strategies to ensure cardiologist review of referrals might pose further delays in transfer. Six patients were discharged following a total hospital stay (at either the referring hospital or PCI centre) of 2 days or less. This highlights a need to ensure that transfer patients receive the same standard of care offered to patients presenting directly to our PCI centre, particularly in respect to education and rehabilitation following myocardial infarction.

Study limitations—This small, retrospective, observational study was not intended to compare reperfusion strategies in STEMI or to prove any important clinical outcomes, including cost-effectiveness. Our aim was to determine the feasibility of transfer PPCI in this local population. Although not collected prospectively, data was reliably documented, with the exception of symptom onset, which was patient-reported.

These results may not be generalisable due to some of the characteristics of our local situation, including long-distance transfer, local flying conditions, low-density population and other factors unique to New Zealand. However, this experience might provide a benchmark for similar settings where a parent PCI centre provides CCL services for a neighbouring hospital dependent on helicopter transport in emergencies. Most current international data are over shorter transfer distances and in much more populous settings which might not be applicable to our local experience.

Future directions—Although the greatest delay occurred at the referring hospital, small improvements in all intervals during transfer could result in large improvements in overall rates of patients achieving optimal targets. Fundamental measures to reduce DTB times have been well described,[21, 22] with pre-hospital activation of STEMI transfer protocols significantly reducing transfer times.[24] A significant proportion of our patients (42%) had pre-hospital ECGs demonstrating clear ST segment elevation yet experienced the obligatory delay resulting from triage at the referring hospital. If guideline-directed DTB times are to be achieved in our transfer population, pre-hospital ECG transmission warrants consideration.

Transfer that is clearly not feasible within an appointed timeframe must be identified early, so that these patients can be promptly diverted into a fibrinolytic treatment pathway. Such strategies have been applied in international models.[12] Given some evidence suggesting that fibrinolysis might achieve similar in-hospital mortality to PPCI in patients presenting less than 3 hours from symptom onset,[7] patient triage according to time from symptom onset might assist in the decision making process, particularly if delays are anticipated.

Recent evidence has highlighted the importance of patient-specific risk in establishing an acceptable time delay to PPCI.[23] The use of a PPCI strategy where DTB time exceeds door-to-needle time by up to 114 minutes might be reasonable in selected patients (older than 65, anterior MI).[17] However, given that 27% of patients receiving fibrinolysis fail to reperfuse,[25] often resulting in delayed, emergent transfer for rescue angioplasty, caution must be employed in taking any delay.

While greater consideration should be given to high risk features in the algorithm in order to identify patients who might be better served with a transfer strategy, the accurate and rapid triage of patients in an emergency setting is enhanced by employing simple triage pathways.

Conclusion—A protocol for rapid helicopter transfer for PPCI from Whangarei to Auckland Hospital was developed and trialled. This has allowed for the routine consideration of PCI as a primary reperfusion strategy in a population presenting to a non-PCI centre without the option of road transfer. Although the DTB times achieved did not consistently meet accepted guidelines, our experience compares favourably with other real-world reports.

Furthermore, a significant proportion of patients missed guideline-based targets by a small margin so minor improvements should yield better outcomes. In many cases, unacceptable delays occurred but we have demonstrated that transfer PPCI is a feasible strategy for patients presenting with STEMI to a partner hospital. Improvements in the early triage of patients and early consideration of treatment alternatives are required if the full benefits of this strategy are to be realised.

Competing interests: None known.

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