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PREHOSPITAL THROMBOLYSIS IN REGIONAL TASMANIA: A RETROSPECTIVE COHORT STUDY

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ABSTRACT

Background: Patients with ST-elevation myocardial infarction (STEMI) in regional Tasmania frequently encounter reperfusion delays. A 2020 review revealed an average first medical contact (FMC) to in-hospital thrombolysis time of 76.4 minutes. Ambulance Tasmania subsequently implemented prehospital thrombolysis (PHT) as part of a pharmacoinvasive strategy. This study aimed to describe a cohort of the first patient encounters treated under the PHT guideline.

Methods: This was a descriptive, retrospective cohort study of the first 30 consecutive patient encounters involving PHT from August 2021 to October 2022. Paramedics identified patients with STEMI and transmitted the ECG for approval. An Intensive Care Paramedic (ICP) administered Tenecteplase™, and patients were transported directly to a PCI-capable hospital. Quantitative data on PHT quality indicators were collected from the electronic patient care records using a Utstein-style tool.

Results: Despite meeting reperfusion targets in only two cases, the average time of 52 minutes from FMC to thrombolysis was 32% faster (24.4 minutes) than pre-PHT. When an ICP attended first (n=7), the needle times were significantly shorter at 39 minutes. The median symptom onset to needle time was 94 minutes (IQR=89). On average, scene times increased from 20 to 44.5 minutes with PHT, and patients arrived at the PCI center 124 minutes after FMC. There were no significant adverse events reported. Notwithstanding signs of successful PHT for 70% (n=21) of patients, 60% (n=18) were admitted directly to the catheterization lab for angiography and PCI.

Conclusion: This study describes a cohort of patients treated under a new PHT guideline in regional Tasmania where reperfusion targets were not being met. There were no reported safety incidents and the time from FMC to needle showed improvement compared to historical practice. Additional research is required to continue to improve times and optimize PHT as part of a broader pharmacoinvasive strategy.

INTRODUCTION

Achieving coronary revascularisation through either primary percutaneous coronary intervention (pPCI) or thrombolytic administration continues to be the mainstay of treatment for patients with ST elevation myocardial infarction (STEMI). Irrespective of the treatment regime, patient outcome is primarily impacted by the time interval from symptom onset to coronary reperfusion (Bagai et al., 2014; Ellis, 1997; Park et al., 2019).

Outcomes for patients with STEMI are directly related to total ischemic time, with the greatest benefit occurring when reperfusion is achieved within the first two hours of infarction (Brodie et al., 1998). As the effectiveness of thrombolysis declines with increasing time from symptom onset to administration, the importance of early management cannot be understated (Boersma et al., 1996; Weaver, 1995). While international research has evolved over 30 years to support pPCI as the preferred option if performed promptly, the lack of access to cardiac centers and resultant delays to pPCI in regional and outer metropolitan areas make prehospital thrombolysis (PHT) an accepted alternate reperfusion strategy (Boersma & Group, 2006; Ellis, 1997; O'Connor et al., 2015; Park et al., 2019; Weaver et al., 1997).

A combined 'pharmacoinvasive' approach involves the delivery of early thrombolysis followed by transfer to a PCI-capable center for angiography within 24 hours, regardless of the apparent success of thrombolysis (Armstrong et al., 2013). Elements of this strategy were explored in the TRANSFER-AMI trial, which reported a reduction in recurrent ischemia, cardiogenic shock, and heart failure in patients who received thrombolysis and routine angiography when compared to an ischemia-guided approach (Cantor et al., 2009). Similarly, the STREAM trial compared thrombolysis with angiography within 24 hours to delayed pPCI for patients who had an anticipated delay of >60 minutes to PCI. The study found no difference in mortality between the groups, demonstrating that the pharmacoinvasive approach is at least as effective for those patients who may experience a delay to pPCI (Armstrong et al., 2013). By routinely transferring patients to a PCI center for angiography post thrombolysis, the pharmacoinvasive approach balances the benefit of early reperfusion with the increased risk of re-occlusion and re-infarction associated with thrombolysis (Bainey et al., 2019). Consensus guidelines published by the National Heart Foundation of Australia and the Cardiac Society of Australia and New Zealand (CSANZ) recommend that patients be treated with pPCI if completed within 90 minutes of first medical contact (FMC) (Chew et al., 2016). Alternately, a pharmacoinvasive approach is recommended for patients facing a delay in completing pPCI beyond 90 minutes. Following this approach, patients are treated with thrombolysis within 30 minutes of FMC followed by scheduled angiography within 24 hours if it is successful or immediately if it fails (Chew et al., 2016; Welsh et al., 2022). Primary failure of thrombolysis is suspected when there is a less than 50% reduction in ST-segment elevation or ongoing symptoms of ischemia at 60-90 minutes post thrombolysis despite ECG improvement (Chew et al., 2016).

In the out-of-hospital environment, paramedics have an important role in ensuring patients with STEMI receive timely reperfusion (Martin et al., 2020). Paramedic initiation of PHT or direct referral to pPCI significantly reduces the time to coronary reperfusion (Björklund et al., 2006; Chew et al., 2016; Morrow et al., 2002). Starting in 2008, several Australian ambulance services implemented PHT as part of a pharmacoinvasive approach (Doan et al., 2020; Khan et al., 2016; Murdoch et al., 2016). In comparison, paramedics in some areas of the United Kingdom and North America began administering PHT in the 1990s (Kuhn et al., 1993; Weaver et al., 1990; Welsh et al., 2022), while other services added PHT guidelines more recently (Guy et al., 2021). Not all Australian states have adopted PHT, and reperfusion strategies across STEMI networks remain varied given geographical differences and timely access to pPCI, highlighting the lack of a 'one size fits all' approach (Wilkinson-Stokes, 2023).

In regional Tasmania, many patients are located too far from the two PCI centers to arrive within the 90-minute window for pPCI. Before 2021, Ambulance Tasmania's (AT) approach to managing STEMI in these areas relied on rapid transport to the closest hospital for thrombolysis, followed by secondary transfer to a PCI-capable center. Notwithstanding the evidence for PHT, AT had not implemented the process for multiple reasons. Contributing factors included a perceived lack of readiness and low-risk tolerance by those responsible for clinical governance (Acker, 2023). A 2020 quality review of 22 patients from the Northwest region of Tasmania with prehospital recognized STEMI from February 2019 to July 31, 2020, revealed a mean 'FMC to in-hospital thrombolysis' time of 76.4 minutes. In addition, it took an average of almost 200 minutes from FMC for these patients to arrive at the PCI-capable hospital post-thrombolysis (Oatley, 2021). Temporary hospital closures and care delays related to the COVID-19 pandemic were expected to further increase the time to treatment. The review revealed how patients in this region rarely achieved national and international reperfusion targets despite mean ambulance response times of 13.5 minutes (SD=9) for STEMI and mean scene times of 20 minutes (SD=7.8) (Oatley, 2021).

Responding to review findings, Clinical Services at AT collaborated with key stakeholders in Tasmania Health Service to overcome any remaining barriers and paramedics began administering PHT in regional areas beginning in August 2021. Adopting a pharmacoinvasive strategy, paramedics would transport patients directly to a PCI-capable hospital post-PHT for scheduled angiography within 24 hours or rescue/urgent PCI if clinically indicated. Developing this collaborative and cross-organization reperfusion strategy involved a significant investment in workforce consultation, clinical practice guideline (CPG) development, medication procurement, and staff education.

Utilizing a Utstein-style data reporting tool, this study aimed to describe a cohort of the first patient encounters treated under the Ambulance Tasmania prehospital thrombolysis clinical practice guideline. The findings will be used to make recommendations to AT and the Tasmanian Health Service and inform the ongoing implementation of a statewide reperfusion strategy in regional and outer metropolitan areas.

METHODS

Study Design

This was a descriptive, retrospective cohort study of the first 30 consecutive patient encounters involving prehospital thrombolysis for STEMI at Ambulance Tasmania from August 2021 to October 2022.

Setting

With a decentralized population of approximately 573,000 people over 68,401 km^2, the Australian state of Tasmania has a relatively large burden of cardiovascular disease (Australian Bureau of Statistics, 2022; Howes, 2020). Within Tasmania are two centrally located PCI centers, one each in the north and south. There are 15 hospitals or health centers capable of providing thrombolytic therapy across the state, with 5 in the Northwest region. The drive time from communities in the far northwest region is approximately 3.5 hours to the northern PCI center and 4.25 hours to the southern location. Ambulance Tasmania is the sole provider of emergency ambulance services, responding to 98,000

cases annually (Australian Government, 2024). The primary response ambulances are typically staffed with tertiary educated Ambulance Paramedics (AP) whose scope of practice includes intravenous (IV) cannulation and drug administration, supraglottic airway insertion, and 12 lead electrocardiogram (ECG) interpretation. Intensive Care Paramedics (ICP) in solo response vehicles provide clinical backup and a broader scope of practice, including endotracheal intubation, synchronized cardioversion, and transcutaneous pacing. Critical Care and Retrieval (CCR) teams with a flight ICP and retrieval physician also perform scene responses by either ground, fixed wing or rotary-wing ambulance. Additionally, AT relies on volunteer ambulance officers to support paramedics in regional and remote areas.

Intervention

Adapted from the THS, Queensland Ambulance Service and Ambulance Victoria, the new PHT clinical practice guideline (Appendix 1) is indicated for patients presenting within 12 hours of onset of typical symptoms of acute myocardial infarction lasting at least 20 minutes. The patient's ECG must meet traditional STEMI criteria and be transmitted for review by a retrieval physician before treatment. The Zoll™ monitor used in AT is not programmed to facilitate the direct electronic transfer of 12 lead ECGs. Thus, paramedics use a mobile telephone to capture de-identified images of the patient's 12 lead ECG to send via email.

The ICPs completed an online training package followed by a four-hour face-to-face education session on PHT. With simulated scenarios, they were given hands-on experience using the thrombolysis administration kits. Per the CPG, patients are eligible for PHT if the estimated transport time from STEMI identification to arrival at a PCI-capable hospital exceeds 60 minutes. This accounts for a 30-minute door-to-balloon time to make up the 90 minutes stipulated by CSANZ. Only ICPs are authorized to initiate PHT under the current guidelines with plans to expand to APs. This decision was made in part due to an international shortage of Tenecteplase™ at the time of implementation.

The closest ambulance is assigned to respond to emergent 000 calls (i.e. chest pain/shortness of breath). Additional resources are deployed if the caller advises that the patient's condition has deteriorated or when the first ambulance crew requests them. For the highest priority cases (i.e. cardiac arrest), the highest level paramedic available is dispatched in addition to the closest ambulance.

Any paramedic who identifies a STEMI can initiate the 'CODE STEMI' process by using a smartphone to transmit the ECG for review by a retrieval physician 24/7. Once approved, the APs continue providing Acute Coronary Syndrome (ACS) care and either wait on the scene or initiate transport to rendezvous with ICP backup, who will perform PHT. If CCR responds to the scene, that attending team can also initiate PHT. All patients also receive a standard bundle of care for ACS. This includes aspirin, glyceryl trinitrate, pain relief with morphine or fentanyl, and antiemetics. Patients are transported directly to a PCI center post-PHT.

Participants

Participants for this study were identified through a retrospective record review of patients treated under the newly implemented PHT guideline. Study data were collect-

ed from patient encounters documented by paramedics in the STEMI quality assurance reporting registry and the electronic patient care record (ePCR). Paramedics document details of every case using Victorian Ambulance Clinical Information System (VACIS) software. Patient encounters were included if the patient received paramedic-administered PHT under the CPG during the study period. Patients who received intra-arrest Tenecteplase™ by CCR retrieval physicians outside of the paramedic practice guidelines and those who met the CPG inclusion criteria but were deemed ineligible according to the reperfusion checklist (i.e., due to hypertension) were excluded from the study (Figure 1).

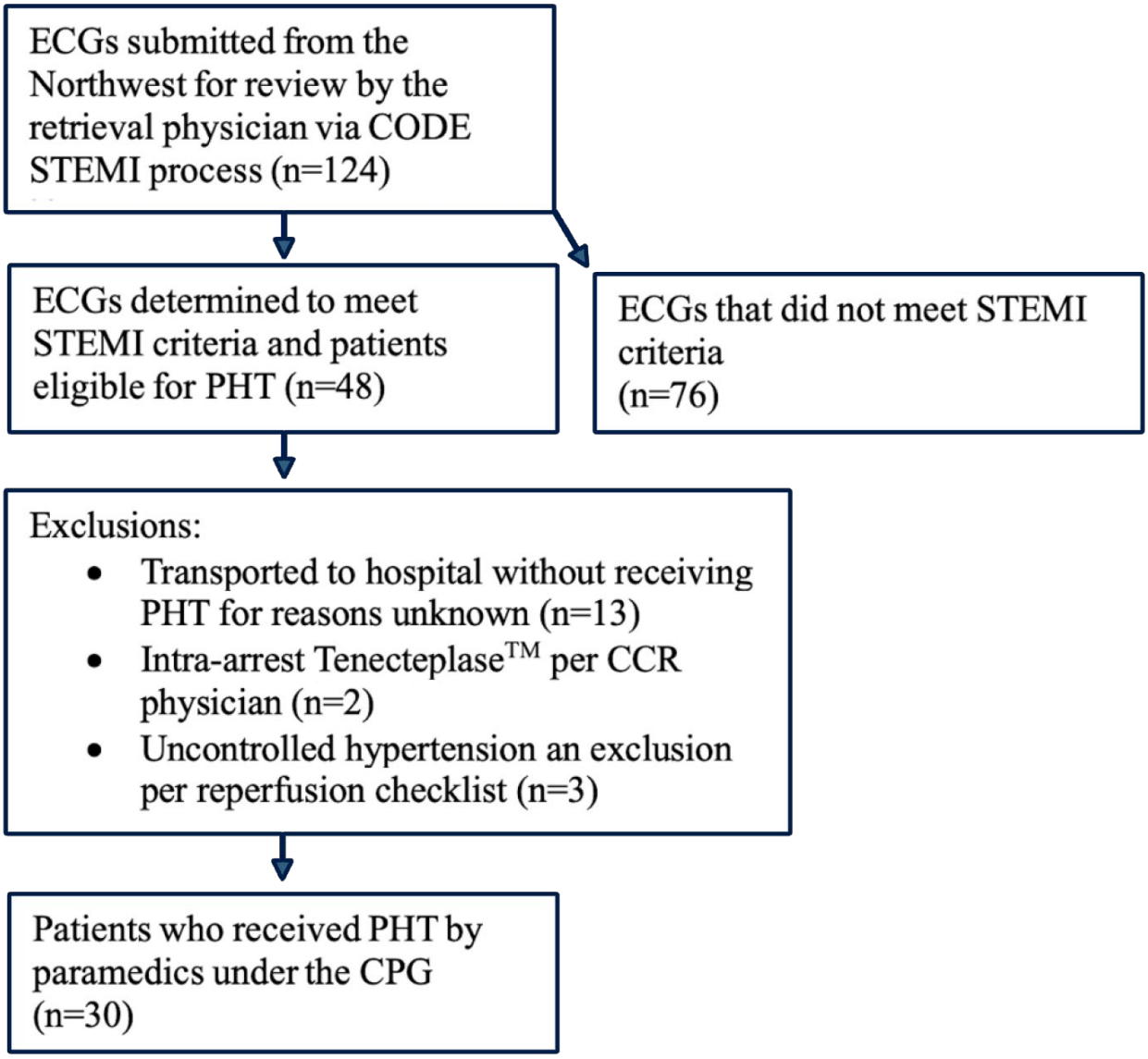


Figure 1. Potential patients eligible for prehospital thrombolysis and exclusion reasons.

Note: ECG - electrocardiograph, STEMI - ST-elevation myocardial infarction, PHT - prehospital thrombolysis, CCR - critical care retrieval, & CPG - clinical practice guidelines.

Variables

To inform data collection, the researchers first conducted a scoping review of the current literature to identify clinical quality indicators and influencing factors associated with prehospital STEMI and thrombolysis. This was necessary because a standard reporting tool for PHT does not yet exist (Jenkins et al., 2024). The variables were aligned to the five key domains found in Utstein-style reports. Representing consensus reporting guidelines, Utstein-style reporting is an internationally recognized framework used to benchmark and evaluate out-of-hospital cardiac arrest, major trauma, prehospital airway management, and ambulance dispatch (Castrén et al., 2008; Dick & Baskett, 1999; Langhelle et al., 2005; Nolan et al., 2019). This approach for data collection was selected to produce standardized reporting in this area. The data extraction tool, based on a proposed PHT reporting tool (Appendix 2), is presented in Table 1. To align with standardized terminology, thrombolysis administration time is identified as 'needle time'. The scene time was calculated by subtracting the ambulance 'transport time' from the 'first medical contact' arrival time. The transport time was calculated by subtracting the 'arrival at destination hospital' time from the primary ambulance 'transport time'.

System, Recognition, & Dispatch and Patient	PHT Processes	Outcomes
Time of day of 000 call	FMC to ECG	Adverse events
Skill level of attending crew	FMC to needle time	Change in ST elevation
Location of patient	Scene time	Change in chest pain score
Time of 000 call to FMC	Transport time to hospital	Rescue PCI
Symptom onset to FMC	Time PHT to PCI hospital	Culprit vessel
Age		Flow at angiography
Gender		Survival to hospital
Past medical history		Survival to discharge
Allergies		Survival at 30 days
Contraindications to PHT		
STEMI location		

FMC – first medical contact, PHT – prehospital thrombolysis, STEMI – ST-elevation myocardial infarction, ECG – electrocardiograph, PCI – percutaneous coronary intervention

Table 1. Data collection tool - PHT quality indicators per Utstein-style domains.

Data sources

Patient encounters for this study were identified through the CODE STEMI registry. A data analyst also performed a search on the documented administration of 'Tenecteplase' in VACIS during the study period to validate that there were no missing events. We applied the inclusion and exclusion criteria to the cases documented in the CODE STEMI registry to include all patients who received PHT while excluding those who were approved for PHT but did not receive it for any reason and those who were treated by CCR physicians outside of the paramedic PHT guidelines.

Using the data extraction tool, two researchers (TJ & LO) collected prehospital data from the CODE STEMI registry and ePCR forms in VACIS. Angiography, hospital ECGs, and mortality results were sourced from the registry and electronic medical records by two researchers (AB & SE). Study data was extracted and coded against five Utstein domains:

system, recognition and dispatch, patient, process, and outcomes. Data elements were defined per the European Society of Cardiology (ESC) guidelines (Byrne et al., 2023).

Bias

We aimed to reduce bias and ensure trustworthiness in our data and reported findings. Two authors drafted the initial Utstein-like data collection tool (SM & LJ). Two others (TJ & LO) sought feedback from clinicians with expert knowledge of PHT and incorporated the feedback. SM initially test-piloted the data collection tool and made minor changes to the final version. During data collection, two researchers (LJ & TJ) applied the exclusion criteria, and one researcher (TJ) reviewed all 30 included cases to confirm the accuracy of the data. The authors followed the STROBE reporting guideline for cohort studies to maintain methodological quality and address bias in the design, quality, and analysis of this report (Von Elm et al., 2008).

Statistical Analysis

Data were collated in Microsoft Excel™ 2020 and analyzed using Statistical Package for the Social Sciences (SPSS), Version 29 (SPSS Inc., Chicago, IL). Categorical values are described using frequencies (n) and percentages (%). Continuous data are reported using mean, median, and standard deviation or interquartile ranges, dependent on normality of distribution, which was assessed using the Shapiro–Wilk test. Independent sample t-tests for parametric data were used for between group comparisons of continuous variables and Mann-Whitney U tests for non-parametric data.

Ethics

The Charles Sturt Human Research Ethics Committee (HREC) granted ethical approval for this study (HREC approval H22157). The AT executive committee also approved this research.

RESULTS

During the study period, 124 ECGs were submitted as part of CODE STEMI in the Northwest region. Of these, 48 (38.7%) ECGs were confirmed as meeting STEMI criteria, and 13/48 patients were transported directly to the hospital without PHT for reasons unknown. A total of 30 (62.5%) patients met the criteria for and received PHT by AT paramedics within the recruitment period and were included in the study. Two other patients were given intra-arrest Tenecteplase™ by CCR physicians and an additional three patients met the inclusion criteria for the CPG but were deemed ineligible for PHT due to uncontrolled hypertension. These five patients were not included in the study.

System, Recognition and Dispatch, Patient Domains

Following the Utstein-style reporting domains, data describing the emergency medical system, STEMI recognition, ambulance dispatch, and patient demographics are presented in Table 2.

The 30 patients included in the study were predominantly male (n=24, 80%) with an average age of 63.4 years (44-92, SD=11.6). Over half (n=16, 53%) had a documented history of hypertension and presented with an inferior STEMI. There were 53% (n=16) of patients who contacted 000 between 0800h and 1600h after experiencing symptoms for a median

Data per Utstein-Style Reporting Domains	
System	n (%)
Time of day of 000 call (between 0800-1600h)	16 (53)
Skill level of first attending paramedic (AP)	23 (77)
Recognition and Dispatch	min (IQR)
Symptom onset to FMC[a]	44.5 (65)
000 call to FMC (all paramedics)	14 (11)
000 call to FMC (AP)	11 (11)
000 call to FMC (ICP)	18 (16)
Patient	n (%)
Age (y)	63.4 (SD=11.6)
Gender (male)	24 (80)
Past medical history	
• Hypertension	16 (53)
• Hypercholesterolemia	5 (17)
• NIDDM	4 (13)
• Coronary stent	4 (13)
• COPD	3 (10)
• Atrial fibrillation	2 (7)
• Malignancy	1 (3)
• Stroke/TIA	1 (3)
Relative contraindication to PHT (%)	5 (17)
Location of STEMI (% inferior)	16 (53)
[a] n=28 as data missing in 2 events	
PHT – prehospital thrombolysis, AP – Ambulance Paramedic, ICP – Intensive Care Paramedic, FMC – first medical contact, BPM – beats per minute, NIDDM – non-insulin dependent diabetes mellitus, COPD – chronic obstructive pulmonary disease, TIA – transient ischemic attack, STEMI – ST-elevation myocardial infarction	

Table 2. Data describing system, recognition and response, and patient.

Data per Utstein-Style Reporting Domain	
Prehospital Thrombolysis Process	Mean (SD)
FMC to ECG (min)	4 (4)
FMC to needle time (min)	52 (15)
FMC to needle time (min) (APs)	55 (10)
FMC to needle time (min) (ICPs)	39 (14)
Time on scene (min)	44.5 (17)
Transport scene to PCI center (min)	79 (22)
Needle time to arrival at PCI center (min)	68 (22)
FMC to arrival at PCI center (min)	124 (19)
Prehospital Thrombolysis Process	Median (IQR)
Symptom onset to needle time (min)[a]	94 (89)
Medications Administered	n (%)
Aspirin[b]	27 (90)
Atropine	1 (3)
Clopidogrel	30 (100)
Enoxaparin	30 (100)
Fentanyl	23 (77)
Glyceryl trinitrate (nitroglycerin)	11 (37)
Morphine	1 (3)
Ondansetron	20 (67)
Oxygen	6 (20)
Tenecteplase	30 (100)
[a] n=28 as data missing in 2 events, [b] administered before arrival in 2 events and not documented in 1 event	
FMC – first medical contact, ECG – electrocardiograph, PCI – percutaneous coronary intervention	

Table 3. Data describing the prehospital thrombolysis process.

time of 44.5 minutes (IQR 65). The majority (n=23, 77%) were initially treated by Ambulance Paramedics who responded within a median time of 14 minutes (IQR=11) and were subsequently supported by an ICP to perform PHT. A Mann-Whitney U test (U=57.5, p-0.257) showed that the difference in time between 000 call and FMC was not statistically different between the APs (median = 11) and ICPs (median = 18).

Prehospital Thrombolysis Process Domain

The PHT process was primarily evaluated in terms of time intervals (Table 3). Patients received their first ECG in a mean documented time of 4 minutes (SD=4) after paramedics arrived. They were administered Tenecteplase™, a mean average of 52 minutes (SD=15) after FMC by a paramedic at any level, which represents a 32% improvement over the reported historical cohort time of 76.4 minutes. When an ICP was the first paramedic on the scene (n=7, 23%), the FMC to needle time averaged 39 minutes as compared to 55 minutes when an AP crew arrived first (Figure 2). This was a significantly faster FMC to needle time, t(28) = 3.388, p=0.02. The median symptom onset to needle time was 94 minutes (IQR=89).

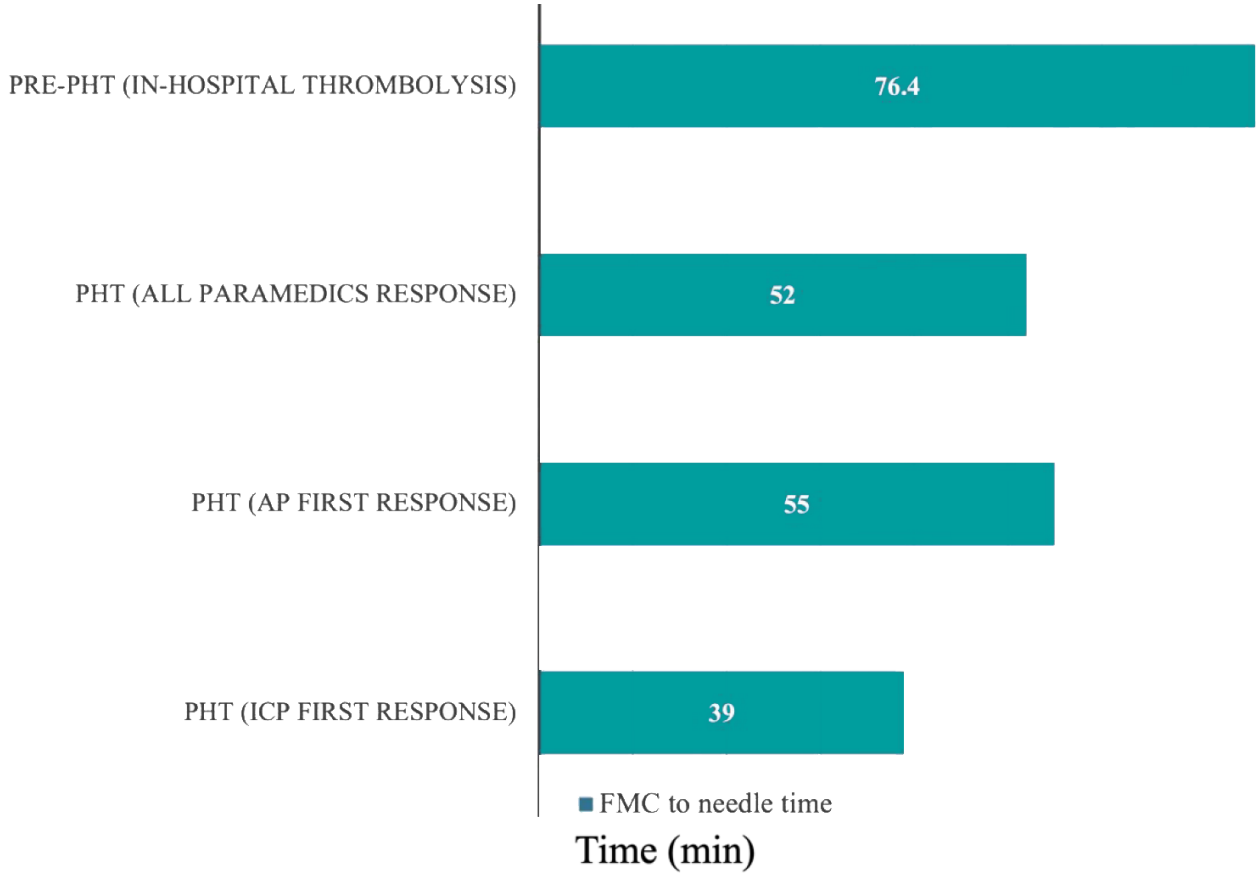


Figure 2. FMC to needle times pre and post-PHT with a comparison of AP and ICP first response to the scene. (FMC - First Medical Contact, PHT - PreHospital Thrombolysis, AP - Ambulance Paramedic, ICP - Intensive Care Paramedic, & PCI - Percutaneous Coronary Intervention.)

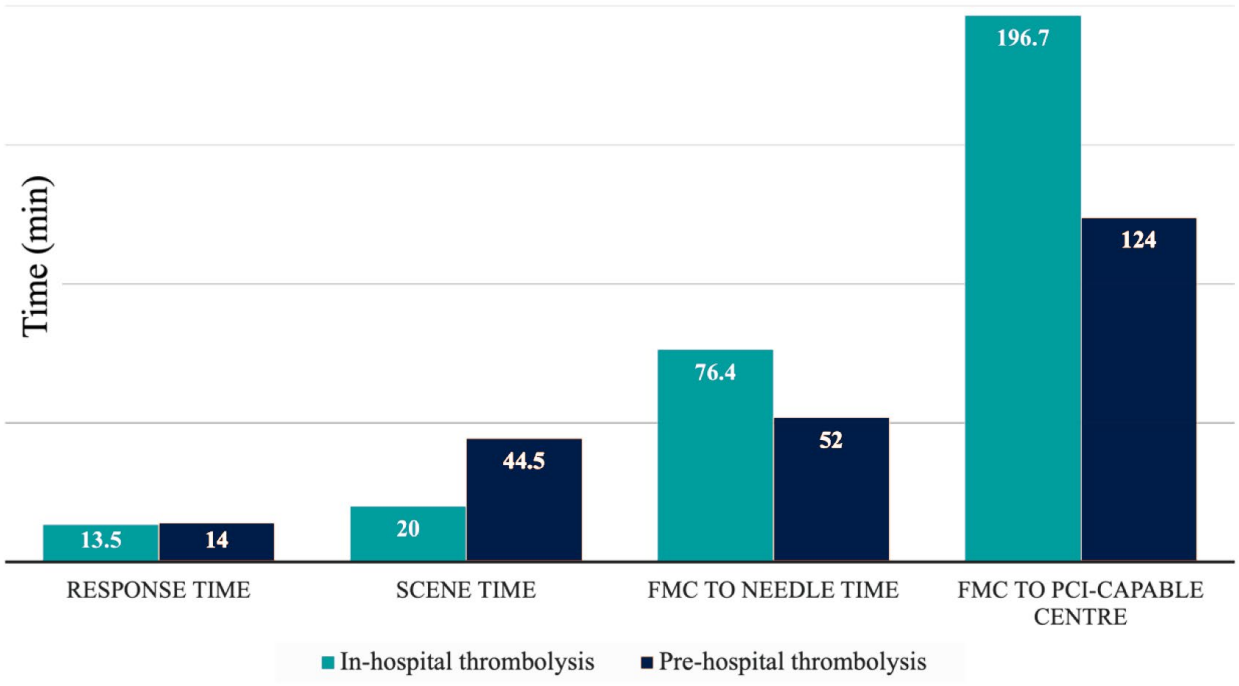


Figure 3. Comparison of historical in-hospital and post-PHT times. (FMC - First Medical Contact, PCI - percutaneous coronary intervention)

Paramedics had an average scene time of 44.5 minutes (SD=17) during the study, which was over two times longer than the historical cohort of 20 minutes (SD=7.8). Patients were transported directly to a PCI-capable hospital and arrived an average of 124 minutes (SD=19) after FMC. This is 72.7 minutes (37%) faster than previous practice when a secondary transfer was required. Figure 3 illustrates a comparison of historical in-hospital and post-PHT times.

Outcome Domain

Patient outcomes in this study were measured during the prehospital and in-hospital phases (Table 4). In the prehospital setting, paramedics documented improved ST changes on the ECG in 60% (n=18) of patients and reduced chest pain by a score of 2/10 or more in 77% (n=23) of patients upon arrival at the hospital. Paramedics documented repeated ECGs in 10 (33%) of patient events and data describing prehospital ECG changes post-PHT was missing in 4 cases (13%). There were no documented cases of major bleeding; the right coronary artery was the culprit vessel in most cases (n=18, 60%), and all patients survived to 30 days post-discharge from the hospital.

Data per Utstein-Style Reporting Domain	
Outcome	**n (%)**
Improved ST elevation >= 50% prehospitala	18 (60)
No improvement of ST elevation prehospital[a]	6 (20)
Transient ST elevation improvement (reinfarction)[a]	2 (7)
Improved ST elevation >= 50% in-hospital	21 (70)
Reduced chest pain (>2 VAS) prehospital	23 (77)
Chest pain completely resolved prehospital	11 (37)
Rescue PCI[b]	18 (60)
Flow at angiography	24 (80)
Major bleeding	0 (0)
Survival to hospital	30 (100)
Survival to hospital discharge	30 (100)
Survival at 30 days	30 (100)
Culprit vessel	
RCA	18 (60)
LAD	10 (33)
Multi-vessel	1 (3)
Other[c]	1 (3)
[a] from initial prehospital ECG to arrival at hospital, [b] bypass emergency department and transfer direct to PCI lab, [c]Takotsubo	
PCI –percutaneous coronary intervention, LAD – left anterior descending, LCx – left circumflex, RCA – right coronary artery, VAS – visual analogue scale	

Table 4. Data describing outcomes post-thrombolysis and percutaneous intervention.

60% (n=18) of patients bypassed the emergency department and were transported directly to the PCI laboratory upon arrival at the hospital. Angiography demonstrated that coronary reperfusion had occurred in 80% of patients (n=24) who were transferred directly to the PCI laboratory on arrival at a PCI-capable hospital. This reperfusion had occurred before any percutaneous intervention was performed. One patient in the study was found to have Takotsubo cardiomyopathy.

DISCUSSION

The purpose of this study was to describe a cohort of the first patient encounters involving STEMI treated under the newly implemented AT PHT guideline. Using the Utstein-style approach to data collection, the findings indicate that PHT as part of a pharmacoinvasive strategy in Tasmania reduced time to intervention and was not associated with increased harm compared with previous practice. The data highlighted a relatively high rate of what appeared to be 'rescue PCI' despite low rates of primary failure of thrombolysis identified clinically and on angiography.

Adverse Events and Mortality

Consistent with the literature on the safety of PHT (McCaul et al., 2014), there were no reported incidences of allergic reactions, severe bleeding, or intracranial hemorrhage in the study group. All patients survived to 30 days post-discharge from the hospital. While the sample size is very small, these results align with the background literature, which reports low incidences of adverse reactions or death from any cause at 1.9-6.7% following treatment with PHT (Armstrong et al., 2013; Bainey et al., 2019; Khan et al., 2020).

Timing

When the PHT process was introduced in Tasmania, our findings indicated that patients with STEMI in the Northwest region received thrombolysis an average of 52 minutes (SD=15) after contacting 000. This indicates a 32% improvement when compared to the pre-PHT quality review when patients were reportedly thrombolysed in-hospital an average of 76.4 minutes after FMC. The time was significantly faster (39 minutes, $t(28) = 3.388$, $p=0.02$) when an ICP was first on the scene compared to APs. Despite these improved results, only two patients (7%) in the study were administered PHT within the recommended 30-minute timeframe from FMC.

The results reveal that the paramedics spent an average of 44.5 minutes (SD=17) at the scene, more than doubling their historical practice of 20 minutes. This may be partially explained by the added complexity involved in performing PHT and the paradigm shift in training that encouraged paramedics to remain on scene until PHT had been performed. While APs can transmit the ECG and initiate the ACS care bundle, the ICP must obtain consent, complete the checklist, and administer PHT medications. The ICPs would also need to receive a handover and confirm patient assessment findings, all of which take additional time. When the APs were first on the scene, they typically arranged to rendezvous with ICP backup en route. When comparing the 'needle' times and 'scene' times in these cases, it is apparent thrombolysis was administered an average of 8 minutes after the AP crew indicated that they were transporting the patient to the hospital. There would have also been instances when the ICPs arrived at the scene before transport, which could have contributed to extended scene times.

Comparable time trends were observed in other Australian ambulance services, prompting the expansion of PHT to paramedics at all clinical levels in Queensland, New South Wales, and Victoria (Doan et al., 2020; Khan et al., 2020; Murdoch et al., 2016). The tiered response model at AT, coupled with extended scene times, has implications on ambulance resourcing, especially in the Northwest region where there are limited ICPs available. While more research is needed to measure the impact in this setting, extending PHT to all paramedic levels could lead to a more efficient use of resources. Furthermore, AT could introduce a team-based approach to the PHT process similar to cardiac arrest management, which has been shown to improve team performance and reduce time (Kim et al., 2018). A future study using implementation science (Johnston et al., 2023) would be valuable to better understand the barriers and enablers to delivering PHT within the recommended 30-minute timeframe.

One strategy to improve times is to eliminate the need for physician consultation in uncomplicated cases. A study conducted in New Zealand showcased this by comparing the safety and efficacy of an autonomous paramedic-initiated approach to a physician

oversight process. They report a 22-minute reduction in the time from symptom onset to needle and a threefold increase in the number of cases meeting the 30-minute recommendation for FMC to needle time (Davis et al., 2020). Notably, there was no rise in the inappropriate administration of thrombolytics, and there was a significant decrease in both 30-day mortality and hospital length of stay for patients in the paramedic-initiated group.

Upon reviewing the time interval from symptom onset to needle, our cohort of patients presented comparatively early. The median time of symptom onset to PHT of 94 minutes (IQR 89 minutes) is lower than >2 hours in some studies (Hanson et al). This contributed to a lower overall total ischemic time, a key metric with a linear relationship between increasing time and mortality (Brodie et al., 1998). Additionally, PHT is more likely to be effective when given early in the disease course, further contributing to a reduction in total ischemic time (Boersma et al., 1996; Weaver et al., 1997).

The interval between FMC to arrival at a PCI center is an important metric influencing total ischemic time for patients with failed thrombolysis (FT) or ischemic complications post-thrombolysis (Madan et al., 2015). This was reported as an average of 124 minutes (SD=19.4) during the study, approximately 71 minutes post-medication administration. Thus, AT's newly implemented CPG resulted in patients arriving at the PCI-capable center an average of 72.7 minutes (37%) sooner post-thrombolysis when compared to historical practice, contributing to a significant decrease in total ischemic time. This has practical implications when assessing the success or failure of thrombolysis. As there is no international guideline on the timing of repeat ECGs and patient clinical symptoms when assessing for FT, studies commonly use a 90-180 minute time frame (Koh et al., 2023). In Australia, interfacility transport for PCI is recommended by CSANZ for FT in-hospital when there is a less than 50% reduction in ST elevation or ongoing symptoms of ischemia at 60-90 minutes post-thrombolysis (Chew et al., 2016). Data from hospital records in this study indicate that 70% of patients (n=21) had a >=50% improvement in ST elevation from their pre-PHT ECG upon admission, which was greater than 60 but less than 90 minutes from PHT. Most patients (n=23, 77%) also experienced a reduction of at least two points in their original chest pain scores in the prehospital phase, and 11 patients (37%) were reportedly pain-free upon arrival. These findings are comparable to the STREAM trial in which 64% of PHT patients were reported to have ECG and/or clinical signs of successful thrombolysis (Armstrong et al., 2013).

The paramedic documentation analyzed for this study revealed important missing details including patient symptom onset time, repeated ECG acquisitions and interpretations, and patient response to treatments. Documentation errors and omissions in fast-paced clinical work settings are a known problem and something that can be improved upon with quality improvement initiatives (Zhang et al., 2022).

Angiography and PCI

Despite our findings suggesting a PHT success rate of over 70%, 18 patients (60%) in the study proceeded directly to the catheterization laboratory, 13 of which were during daytime hours. This practice could be seen to resemble pre-hospital combination-fibrinolysis or facilitated PCI approaches from previous studies (Ellis et al., 2008; Thiele et al., 2005). The average transport time in this study cohort was 79 minutes (SD=22) reflecting

a rural/remote population, unlike studies of facilitated PCI where PHT occurred within 60 minutes of PCI. Despite early reperfusion benefits (Thiele et al., 2005), the ASSENT-4 PCI trial found this approach led to worse outcomes than PCI alone due to increased bleeding (Ellis et al., 2008). While the 18 patients who went for immediate PCI were categorized as 'rescue PCIs' during data collection, we were unable to determine how many of these patients received PCI for failed thrombolysis as opposed to receiving early angiography because it was readily available. Reported rescue PCI rates for ambulance systems following a similar PHT protocol as AT range from 20.1% to 27.3% (Bainey et al., 2019; Doan et al., 2021; Khan et al., 2016). Distal flow was observed during angiography for 80% (n=24) of patients who received PHT which suggests our results were likely comparable to other ambulance systems.

The reason why so many patients were admitted directly to the PCI lab in the setting of clinical reperfusion on arrival at the hospital is likely multifactorial. The processes that occurred during the trial would indicate that angiography and PCI were performed using an unscheduled rather than scheduled approach. This would inevitably have impacted hospital operations and contributed to inefficiencies in a health system already under pressure (Morgan-Wicks, 2023). We suspect that low acquisition rates and poor reporting of repeat ECGs and clinical findings as 'pre-alerts' during paramedic transport could have influenced decisions to proceed directly to the catheterization laboratory, especially when the team was preassembled rather than on call from home. Taking into consideration post-PHT ECG and clinical findings, reperfusion strategies in Tasmania are determined by local cardiology specialists. While the CSANZ guidelines suggest that PCI should be performed between 3 and 24 hours post-PHT to reduce the incidence of ischemic complications (Chew et al., 2016), there is evidence that PCI within 2 hours maintains the reduction in ischemic complications and is not associated with an increase in bleeding events or mortality (Madan et al., 2015). Our findings suggest that there is scope for the ambulance service to continue to work closely with the health service to clarify expectations of the pharmacoinvasive strategy and optimize communication between paramedics and the receiving PCI center. Future research would be useful to look more closely at the reperfusion strategy and processes and should include feedback from paramedics, retrieval physicians, and cardiologists.

Recommendations and Future Research

While the efficacy of an out-of-hospital reperfusion system is clear, this study identified several key challenges that the ambulance service faced when implementing a PHT CPG and process. The Donabedian structure-process-outcome model provides a three-domain framework to examine health service delivery. According to the model, physical structures in healthcare, such as facilities and equipment, interact with and influence processes that determine how care is delivered. Together, these impact patient outcomes (Donabedian & Bashshur, 2003). Following the Donabedian model, we offer several recommendations and suggestions for future research to support the ongoing implementation of PHT in Tasmania.

For the structure domain, we suggest that AT explore the feasibility of enabling the transmission feature of the ZOLL™ monitors. Cloud-based transmission in some settings has resulted in efficiency and time savings (Sejersten et al., 2008). This may streamline PHT approval and facilitate the transmission of repeat ECGs to the receiving hospital.

Next, extending the ability of paramedics at all levels to perform thrombolysis would increase the number of PHT-capable resources available. Future studies on ECG transmission practices and FMC to needle times in Tasmania would be needed to validate the impact of these system changes.

In the process domain, we suggest that AT continue to invest in the ongoing education of their paramedics with a focus on quality documentation, repeated ECGs, and pre-alert communication to the hospitals regarding PHT success. Building on the success of a team-based approach to CPR (Kim et al., 2018), paramedics should be engaged as key stakeholders to improve PHT processes to achieve targeted FMC to needle times. We also encourage AT to continue collaborating with the Tasmanian Health Service to refine the pharmacoinvasive reperfusion strategy and optimize the use of health resources in this region. Quality improvement studies would be able to demonstrate the impact of these process enhancements. Lastly, in the outcome domain, we recommend that AT adopt the Utstein-style data collection tool. With a focus on patient outcomes, this would facilitate standardized reporting, assist in identifying areas for ongoing improvement, and support future research studies (Castrén et al., 2008; Langhelle et al., 2005).

LIMITATIONS

This study had some important limitations. First, the patient encounters were retrospectively recruited by purposive sampling and thus vulnerable to selection and misclassification bias. Second, the patient sample size is very small, limiting generalizability and increasing the impact of statistical outliers on results. The study was also performed in a relatively small Australian state with a specific ambulance staffing and response model, further limiting the generalizability of these descriptive findings. Next, data for this study were retrospectively extracted from written medical records and subject to errors and omissions. We were also unable to report on aspects of the patient encounters that would assist in evaluating the overall process, including the time it took to perform manual ECG transmissions and rendezvous with ICPs. Finally, we did not have data on TIMI scores or any adverse events that may have occurred in the hospital because of PHT.

CONCLUSION

This study describes a cohort of patients treated under a new PHT guideline in regional Tasmania where reperfusion targets were not being met. There were no reported safety incidents, and the time from FMC to needle showed improvement compared to historical practice. Additional research is required to continue to improve times and optimize PHT as part of a broader pharmacoinvasive strategy. Following a Donabedian healthcare improvement model, suggestions for ongoing implementation include exploring cloud-based ECG transmission capability and extending thrombolysis to all paramedics. The service should also engage paramedics as stakeholders to further reduce FMC to needle times using a team-based approach and use quality improvement initiatives to improve clinical documentation and pre-alert communication. Finally, adopting the Utstein-style data collection tool would facilitate standardized reporting and help identify areas for improvement in PHT.

REFERENCES

Acker, J. (2023). Personal communication.

Armstrong, P. W., Gershlick, A. H., Goldstein, P., Wilcox, R., Danays, T., Lambert, Y., Sulimov, V., Rosell Ortiz, F., Ostojic, M., Welsh, R. C., Carvalho, A. C., Nanas, J., Arntz, H.-R., Halvorsen, S., Huber, K., Grajek, S., Fresco, C., Bluhmki, E., Regelin, A., … Van de Werf, F. (2013). Fibrinolysis or primary PCI in ST-segment elevation myocardial infarction. *New England Journal of Medicine, 368*(15), 1379–1387. https://doi.org/10.1056/nejmoa1301092

Australian Bureau of Statistics. (2022). Snapshot of Tasmania https://www.abs.gov.au/articles/snapshot-tas-2021

Bagai, A., Dangas, G. D., Stone, G. W., & Granger, C. B. (2014). Reperfusion strategies in acute coronary syndromes. *Circulation Research, 114*(12), 1918–1928. https://doi.org/10.1161/circresaha.114.302744

Bainey, K. R., Armstrong, P. W., Zheng, Y., Brass, N., Tyrrell, B. D., Leung, R., Westerhout, C. M., & Welsh, R. C. (2019). Pharmacoinvasive strategy versus primary percutaneous coronary intervention in ST-elevation myocardial infarction in clinical practice. *Circulation: Cardiovascular Interventions, 12*(10). https://doi.org/10.1161/circinterventions.119.008059

Björklund, E., Stenestrand, U., Lindbäck, J., Svensson, L., Wallentin, L., Lindahl, B., & on behalf of the, R.-H. I. A. I. (2006). Pre-hospital thrombolysis delivered by paramedics is associated with reduced time delay and mortality in ambulance-transported real-life patients with ST-elevation myocardial infarction. *European Heart Journal, 27*(10), 1146-1152. https://doi.org/10.1093/eurheartj/ehi886

Boersma, E., & Group, T. P. C. A. v. T.-T. C. (2006). Does time matter? A pooled analysis of randomized clinical trials comparing primary percutaneous coronary intervention and in-hospital fibrinolysis in acute myocardial infarction patients. *European Heart Journal, 27*(7), 779-788. https://doi.org/10.1093/eurheartj/ehi810

Boersma, E., Maas, A. C., Deckers, J. W., & Simoons, M. L. (1996). Early thrombolytic treatment in acute myocardial infarction: reappraisal of the golden hour. *The Lancet, 348*(9030), 771–775. https://doi.org/10.1016/s0140-6736(96)02514-7

Brodie, B. R., Stuckey, T. D., Wall, T. C., Kissling, G., Hansen, C. J., Muncy, D. B., Weintraub, R. A., & Kelly, T. A. (1998). Importance of time to reperfusion for 30-day and late survival and recovery of left ventricular function after primary angioplasty for acute myocardial infarction. *Journal of the American College of Cardiology, 32*(5), 1312–1319. https://doi.org/10.1016/s0735-1097(98)00395-7

Byrne, R. A., Rossello, X., Coughlan, J. J., Barbato, E., Berry, C., Chieffo, A., Claeys, M. J., Dan, G.-A., Dweck, M. R., Galbraith, M., Gilard, M., Hinterbuchner, L., Jankowska, E. A., Jüni, P., Kimura, T., Kunadian, V., Leosdottir, M., Lorusso, R., Pedretti, R. F. E., … Zeppenfeld, K. (2023). 2023 ESC Guidelines for the management of acute coronary syndromes. *European Heart Journal, 44*(38), 3720–3826. https://doi.org/10.1093/eurheartj/ehad191

Cantor, W. J., Fitchett, D., Borgundvaag, B., Ducas, J., Heffernan, M., Cohen, E. A., Morrison, L. J., Langer, A., Dzavik, V., Mehta, S. R., Lazzam, C., Schwartz, B., Casanova, A., & Goodman, S. G. (2009). Routine early angioplasty after fibrinolysis for acute myocardial infarction. *New England Journal of Medicine, 360*(26), 2705-2718. https://doi.org/10.1056/NEJMoa0808276

Castrén, M., Karlsten, R., Lippert, F., Christensen, E. F., Bovim, E., Kvam, A. M., Robertson-Steel, I., Overton, J., Kraft, T., Engerstrom, L., & Garcia-Castrill Riego, L. (2008). Recommended guidelines for reporting on emergency medical dispatch when conducting research in emergency medicine: The Utstein style. *Resuscitation, 79*(2), 193-197. https://doi.org/10.1016/j.resuscitation.2008.07.007

Chew, D. P., Scott, I. A., Cullen, L., French, J. K., Briffa, T. G., Tideman, P. A., Woodruffe, S., Kerr, A., Branagan, M., Aylward, P. E. G., & Aylward, P. E. (2016). National Heart Foundation of Australia and Cardiac Society of Australia and New Zealand: Australian clinical guidelines for the management of acute coronary syndromes 2016. *Medical Journal of Australia, 205*(3), 128-133. https://doi.org/10.5694/mja16.00368

Davis, P., Howie, G. J., Dicker, B., & Garrett, N. K. (2020). Paramedic-delivered fibrinolysis in the treatment of ST-elevation myocardial infarction: Comparison of a physician-authorized versus autonomous paramedic approach. *Prehospital Emergency Care, 24*(5), 617-624. https://doi.org/10.1080/10903127.2019.1683661

Dick, W. F., & Baskett, P. J. F. (1999). Recommendations for uniform reporting of data following major trauma — the Utstein style: A report of a Working Party of the International Trauma Anaesthesia and Critical Care Society (ITACCS). *Resuscitation, 42*(2), 81-100. https://doi.org/10.1016/S0300-9572(99)00102-1

Doan, T. N., Schultz, B. V., Rashford, S., Rogers, B., Prior, M., Vollbon, W., & Bosley, E. (2020). Prehospital ST-Segment Elevation Myocardial Infarction (STEMI) in Queensland, Australia: Findings from 11 years of the statewide prehospital reperfusion strategy. *Prehospital Emergency Care, 24*(3), 326-334. https://doi.org/10.1080/10903127.2019.1651433

Doan, T. N., Wilson, K., Schultz, B. V., Rogers, B., Vollbon, W., Prior, M., Rashford, S., & Bosley, E. (2021). Survival in patients with paramedic-identified ST-segment elevation myocardial infarction. *Prehospital Emergency Care, 25*(4), 487-495. https://doi.org/10.1080/10903127.2020.1809753

Donabedian, A., & Bashshur, R. (2003). *An introduction to quality assurance in health care*. Oxford University Press.

Ellis, S. (1997). A clinical trial comparing primary coronary angioplasty with tissue plasminogen activator for acute myocardial infarction. *New England Journal of Medicine, 336*(23), 1621-1628. https://doi.org/10.1056/nejm199706053362301

Ellis, S. G., Tendera, M., de Belder, M. A., van Boven, A. J., Widimsky, P., Janssens, L., Andersen, H. R., Betriu, A., Savonitto, S., Adamus, J., Peruga, J. Z., Kosmider, M., Katz, O., Neunteufl, T., Jorgova, J., Dorobantu, M., Grinfeld, L., Armstrong, P., Brodie, B. R., … Topol, E. J. (2008). Facilitated PCI in patients with ST-elevation myocardial infarction. *New England Journal of Medicine, 358*(21), 2205–2217. https://doi.org/10.1056/nejmoa0706816

Guy, A., Gabers, N., Crisfield, C., Helmer, J., Peterson, S. C., Ganstal, A., Harper, C., Gibson, R., & Dhesi, S. (2021). Collaborative Heart Attack Management Program (CHAMP): Use of prehospital thrombolytics to improve timeliness of STEMI management in British Columbia. *BMJ Open Quality, 10*(4), e001519. https://doi.org/10.1136/bmjoq-2021-001519

Howes, F. A., S. Lin, L. (2020). Cardiovascular risk factors and disease in Tasmanian general practice. Hobart, Tasmania: Primary Health Tasmania Retrieved from https://www.primaryhealthtas.com.au/wp-content/uploads/2021/08/Cardiovascular-disease-in-general-practice-in-Tasmania-2020.pdf

Jenkins, L., Johnston, T., Armour, R., & Maria, S. (2024). Informing Utstein-style reporting guidelines for prehospital thrombolysis: A scoping review. *Australasian Emergency Care, 27*(2), 148–154. https://doi.org/10.1016/j.auec.2023.12.001

Johnston, T., Beaumont-Boileau, R., Acker, J., & Batt, A. M. (2023). Barriers and enablers to implementing intranasal ketamine for Primary Care Paramedics in Canada – A parallel convergent mixed methods study. *Paramedicine, 20*(5), 132–151. https://doi.org/10.1177/27536386231174097

Khan, A. A., Williams, T., Al-Omary, M. S., Feeney, A. L., Majeed, T., Savage, L., Stewart, P., Faddy, S., Collins, N. J., Fletcher, P., & Boyle, A. J. (2020). Pre-hospital thrombolysis for ST-segment elevation myocardial infarction in regional Australia: Long-term follow up. *Internal Medicine Journal, 50*(6), 711–715. Portico. https://doi.org/10.1111/imj.14412

Khan, A. A., Williams, T., Savage, L., Stewart, P., Ashraf, A., Davies, A. J., Faddy, t., Attia, J., Oldmeadow, C., Bhagwandeen, R., Fletcher, P. J., Boyle, A. J., & Faddy, S. (2016). Pre-hospital thrombolysis in ST-segment elevation myocardial infarction: A regional Australian experience. *Medical Journal of Australia, 205*(3), 121-125. https://doi.org/10.5694/mja15.01336

Kim, S., Ahn, K. O., & Jeong, S. (2018). The effect of team-based CPR on outcomes in out of hospital cardiac arrest patients: A meta-analysis. *The American Journal of Emergency Medicine, 36*(2), 248–252. https://doi.org/10.1016/j.ajem.2017.07.089

Koh, H. P., Md Redzuan, A., Mohd Saffian, S., Hassan, H., R. Nagarajah, J., & Ross, N. T. (2023). Mortality outcomes and predictors of failed thrombolysis following STEMI thrombolysis in a non-PCI capable tertiary hospital: A 5-year analysis. *Internal and Emergency Medicine, 18*(4), 1169-1180. https://doi.org/10.1007/s11739-023-03202-1

Kuhn, P., Atzenhofer-Baumgartner, K., Chmelizek, F., Schnoll, F., Ursin, C., Grobl, S. O., Hamberger, A., Kissling, R., Kleinberger, G., Laich, E., Lechner, S., Leeb, R., Zenz, R., Bossaert, L., Fautsch, G., Kalina, M., Afilalo, M., Barriault, J., & Brophy, J. (1993). Prehospital thrombolytic therapy in patients with suspected acute myocardial infarction. *The New England Journal of Medicine, 329*(6), 383-389. https://doi.org/10.1056/NEJM199308053290602

Langhelle, A., Nolan, J., Herlitz, J., Castren, M., Wenzel, V., Soreide, E., Engdahl, J., & Steen, P. A. (2005). Recommended guidelines for reviewing, reporting, and conducting research on post-resuscitation care: The Utstein style. *Resuscitation, 66*(3), 271–283. https://doi.org/10.1016/j.resuscitation.2005.06.005

Madan, M., Halvorsen, S., Di Mario, C., Tan, M., Westerhout, C. M., Cantor, W. J., Le May, M. R., Borgia, F., Piscione, F., Scheller, B., Armstrong, P. W., Fernandez-Aviles, F., Sanchez, P. L., Graham, J. J., Yan, A. T., & Goodman, S. G. (2015). Relationship between time to invasive assessment and clinical outcomes of patients undergoing an early invasive strategy after fibrinolysis for ST-segment elevation myocardial infarction. *JACC: Cardiovascular Interventions, 8*(1), 166–174. https://doi.org/10.1016/j.jcin.2014.09.005

Martin, L. K., Lewis, V. J., Clark, D., Murphy, M. C., Edvardsson, D., Stub, D., & Farouque, O. (2020). Frontline barriers to effective paramedic and emergency nursing STEMI management: clinician perspectives. *Australasian Emergency Care, 23*(2), 126–136. https://doi.org/10.1016/j.auec.2019.12.001

McCaul, M., Lourens, A., & Kredo, T. (2014). Pre-hospital versus in-hospital thrombolysis for ST-elevation myocardial infarction. *Cochrane Database of Systematic Reviews*(9). https://doi.org/10.1002/14651858.CD010191.pub2

Morgan-Wicks, K. (2023). *Demand pressures at Royal Hobart Hospital and Launceston General Hospital*. Retrieved from https://www.health.tas.gov.au/news/media-releases/demand-pressures-royal-hobart-hospital-and-launceston-general-hospital

Morrow, D. A., Antman, E. M., Sayah, A., Schuhwerk, K. C., Giugliano, R. P., deLemos, J. A., Waller, M., Cohen, S. A., Rosenberg, D. G., Cutler, S. S., McCabe, C. H., Walls, R. M., & Braunwald, E. (2002). Evaluation of the time saved byprehospital initiation of reteplase forST-elevation myocardial infarction. *Journal of the American College of Cardiology, 40*(1), 71–77. https://doi.org/10.1016/s0735-1097(02)01936-8

Murdoch, K., Sinclaire, E., Ferrari, D., & Stubb, D. (2016). Pre-hospital thrombolysis in victoria for regional STEMI patients – Is it ready for primetime? An Ambulance Victoria Report of 2 Years of Program Outcomes. *Heart, Lung and Circulation, 25*, S59. https://doi.org/10.1016/j.hlc.2016.06.133

Nolan, J. P., Berg, R. A., Andersen, L. W., Bhanji, F., Chan, P. S., Donnino, M. W., Lim, S. H., Ma, M. H.-M., Nadkarni, V. M., Starks, M. A., Perkins, G. D., Morley, P. T., Soar, J., Aickin, R., Atkins, D. L., Berg, K. M., Bingham, R., Böttiger, B. W., Brooks, S. C., … Welsford, M. (2019). Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein resuscitation registry template for in-hospital cardiac arrest. *Resuscitation, 144*, 166–177. https://doi.org/10.1016/j.resuscitation.2019.08.021

O'Connor, R. E., Al Ali, A. S., Brady, W. J., Ghaemmaghami, C. A., Menon, V., Welsford, M., & Shuster, M. (2015). Part 9: Acute coronary syndromes. *Circulation, 132*(18_suppl_2). https://doi.org/10.1161/cir.0000000000000263

Oatley, L. (2021). *Thrombolysis for STEMI decision paper*. Tasmania: Ambulance Tasmania, Tasmanian Health Service, Department of Health

Park, J., Choi, K. H., Lee, J. M., Kim, H. K., Hwang, D., Rhee, T., Kim, J., Park, T. K., Yang, J. H., Song, Y. B., Choi, J., Hahn, J., Choi, S., Koo, B., Chae, S. C., Cho, M. C., Kim, C. J., Kim, J. H., … Jeong, M. H. (2019). Prognostic implications of door-to-balloon time and onset-to-door time on mortality in patients with ST-segment–elevation myocardial infarction treated with primary percutaneous coronary intervention. *Journal of the American Heart Association, 8*(9). https://doi.org/10.1161/jaha.119.012188

Sejersten, M., Sillesen, M., Hansen, P. R., Nielsen, S. L., Nielsen, H., Trautner, S., Hampton, D., Wagner, G. S., & Clemmensen, P. (2008). Effect on treatment delay of prehospital teletransmission of 12-lead electrocardiogram to a cardiologist for immediate triage and direct referral of patients with ST-segment elevation acute myocardial infarction to primary percutaneous coronary intervention. *The American Journal of Cardiology, 101*(7), 941–946. https://doi.org/10.1016/j.amjcard.2007.11.038

Thiele, H., Engelmann, L., Elsner, K., Kappl, M. J., Storch, W.-H., Rahimi, K., Hartmann, A., Pfeiffer, D., Kneissl, G. D., Schneider, D., Möller, T., Heberling, H. J., Weise, I., & Schuler, G. (2005). Comparison of pre-hospital combination-fibrinolysis plus conventional care with pre-hospital combination-fibrinolysis plus facilitated percutaneous coronary intervention in acute myocardial infarction. *European Heart Journal, 26*(19), 1956–1963. https://doi.org/10.1093/eurheartj/ehi432

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ, 335*(7624), 806–808. https://doi.org/10.1136/bmj.39335.541782.ad

Weaver, W. D. (1995). Time to thrombolytic treatment: Factors affecting delay and their influence on outcome. *Journal of the American College of Cardiology, 25*(7), S3–S9. https://doi.org/10.1016/0735-1097(95)00108-g

Weaver, W. D., Eisenberg, M. S., Martin, J. S., Litwin, P. E., Shaeffer, S. M., Ho, M. T., Kudenchuk, P., Hallstrom, A. P., Cerqueira, M. D., Copass, M. K., Kennedy, J. W., Cobb, L. A., & Ritchie, J. L. (1990). Myocardial infarction triage and intervention project—Phase I: Patient characteristics and feasibility of prehospital initiation of thrombolytic therapy. *Journal of the American College of Cardiology, 15*(5), 925–931. https://doi.org/10.1016/0735-1097(90)90218-e

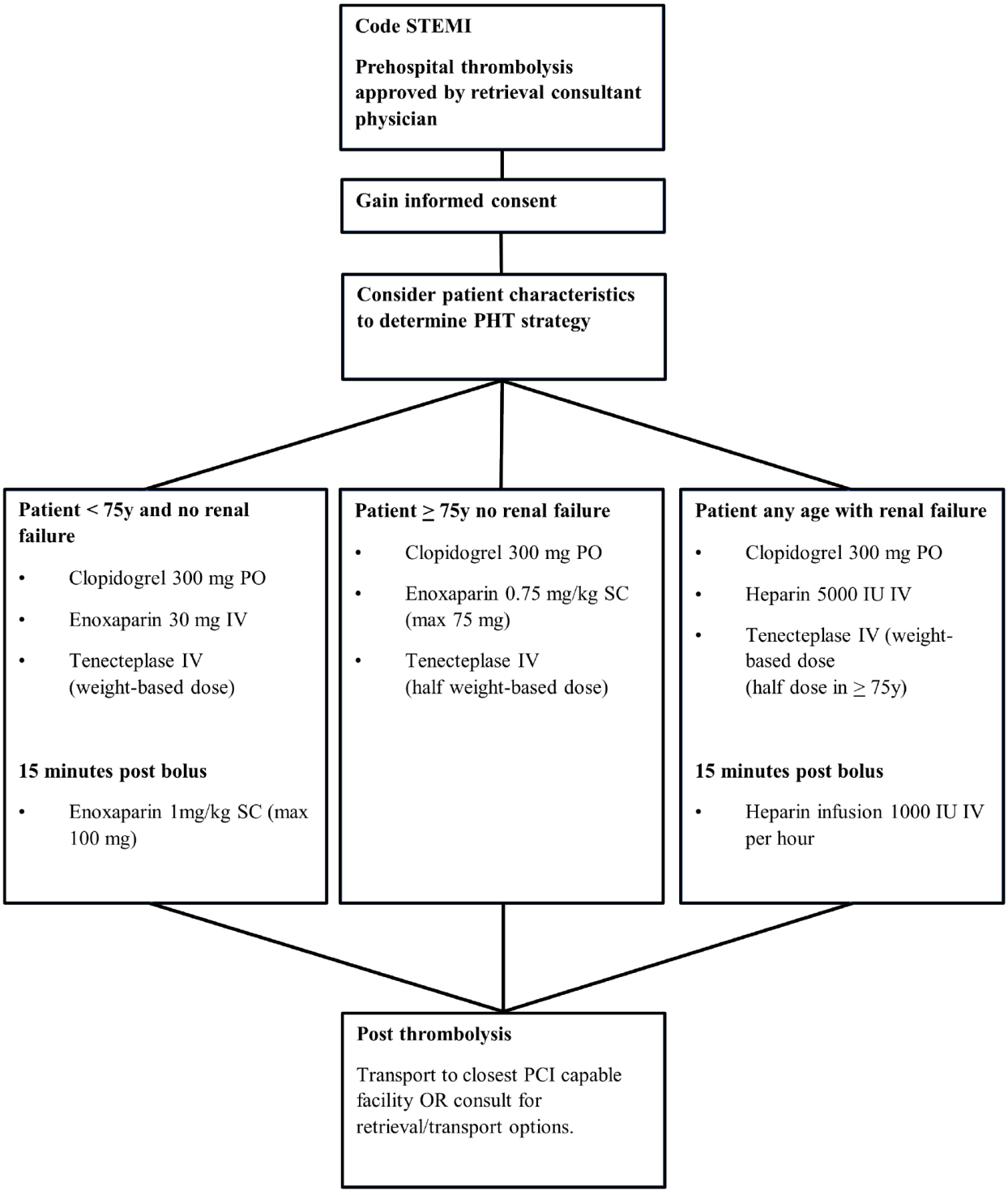
Weaver, W. D. (1997). Comparison of primary coronary angioplasty and intravenous thrombolytic therapy for acute myocardial infarction. *JAMA, 278*(23), 2093. https://doi.org/10.1001/jama.1997.03550230069040

Welsh, R. C., Cantor, W. J., Traboulsi, M., Schampaert, E., & May, M. L. (2022). Primary percutaneous coronary intervention and application of the pharmacoinvasive approach within ST-elevation myocardial infarction care networks. *Canadian Journal of Cardiology, 38*(10), S5–S16. https://doi.org/10.1016/j.cjca.2021.02.023

Wilkinson-Stokes, M. (2023). *The clinical guideline manifesto*. Retrieved March 1, 2024 from https://www.theshiftextension.org/clinical-guideline-manifesto

Zhang, Z., Joy, K., Harris, R., & Park, S. Y. (2022). *Characteristics and challenges of clinical documentation in self-organized fast-paced medical work*. Proceedings of the ACM on Human-Computer Interaction, 6(CSCW2), 1–21. https://doi.org/10.1145/3555111

APPENDIX 1. PREHOSPITAL THROMBOLYSIS CLINICAL PRACTICE GUIDELINE



APPENDIX 2. PROPOSED UTSTEIN-STYLE PREHOSPITAL THROMBOLYSIS STANDARDIZED DATA CAPTURE FORM

Prehospital thrombolysis standardized data capture form for EMS

Population served
Total pop served by EMS
n =

System description	

STEMI cases attended
Total number of cases
n =

Dispatcher Instructed aspirin		Time to EMS arrival
Yes	No	MM:SS
n=	n=	

PHT attempted
Yes
n =

Age		Gender		
n; mean ±SD	Unknown	Male	Female	Other
	n=	n=	n=	n=

PHT not attempted (Potential contraindications)	Recent ICH	Cerebral or facial contra	Aortic dissection	Active bleeding	Uncontrolled hypertension
	n =	n =	n =	n =	n =
	Unknown	Recent stroke or TIA	Known allergy	Recent trauma	> 6 hours symptoms
	n =	n =	n =	n =	

Location	Home	Work	Rec	Public	Educ	Nursing	Other	Unknown
	n =	n =	n =	n =	n =	n =	n =	n =

Timings MM:SS; mean ±SD	Symptom onset to FMC	FMC to ECG	ECG to PHT	FMC to PHT

Improvement / resolution of STE	
Yes	No
n =	n =

First to attend patient	
ALS	BLS
n =	n =

Further backup required	
Yes	No
n =	n =

Aetiology MI classification	Unknown	Type 1	Type 2	Type 3	Type 4a	Type 4b	Type 5
	n =	n =	n =	n =	n =	n =	n =

Outcomes	Survived to hospital		Rescue PCI		Survival 30 days		Survival to discharge	
	Yes	Yes	Yes	No	Yes	No	Yes	No
	n =	n =	n =	n =	n =	n =	n =	n =

Adverse events	Heart failure		Haemorrhage		Arrhythmias		Survival 30 days	
	Yes	No	Yes	No	Yes	No	Yes	No
	n =	n =	n =	n =	n =	n =	n =	n =