REVIEW

Paramedics and pre-hospital management of acute myocardial infarction: diagnosis and reperfusion

S Johnston, R Brightwell, M Ziman

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In this paper, we discuss and critically analyse pre-hospital management of acute myocardial infarction (AMI). It is clear from several large studies that rapid diagnosis and application of thrombolysis reduces morbidity and mortality rates. Strategies that improve time to treatment in the pre-hospital setting are therefore of fundamental importance in the management of this fatal disease. The advantage of 12 lead electrocardiography use by paramedics to diagnose AMI and reduce time to treatment is discussed. Moreover, paramedic application of thrombolysis in the pre-hospital environment is examined. Several studies conducted worldwide support the notion that ambulance services can play a role in minimising time to treatment for patients with AMI. The contribution of early intervention by paramedics trained in critical care is potentially considerable, particularly in the important chain of survival that is often initiated by pre-hospital intervention.

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The effectiveness of early thrombolysis in the management of acute myocardial infarction (AMI) is well established, particularly with regard to its positive effect on mortality rates. However, several factors delay the time to receiving reperfusion therapy. Of particular interest are factors that can be directly influenced by paramedics. This paper will critically analyse advantages and disadvantages of 12 lead electrocardiography and thrombolysis for diagnosis and treatment of AMI pre-hospital.

PATHOPHYSIOLOGY OF ACUTE MYOCARDIAL INFARCTION

AMI is characterised by myocardial tissue damage resulting from substantial intervals of ischaemia, caused by an acute thrombus occluding or narrowing an atherosclerotic artery. Platelet aggregation and activated coagulation increase degeneration of the vessel lumen, while platelet function altered by endothelial changes in the atherosclerotic plaque also contributes to thrombogenesis.[1–4]

PREVALENCE

Approximately 12 million lives are lost annually from the effects of cardiovascular disease (World Health Organisation), making it universally the major cause of death, responsible for 50% and 30% of all deaths in developed and developing

countries, respectively. Moreover, 50% of AMI patients die prior to reaching hospital. Of those who survive, 50% are re-hospitalised within a year and 5–10% suffer a fatal attack.[5]

TREATMENT
Reperfusion therapy

A reduction in cardiac function caused by irreversible necrosis of the myocardium can result from complete occlusion of a cardiac vessel. The resultant ischaemia is reversible if treated within 3–6 hours. Therapy aiding reperfusion of ischaemic cardiac muscle within this critical time period can reduce the extent and severity of damage thereby reducing mortality and morbidity.[6 7] Reperfusion is possible by a variety of procedures including, thrombolysis, percutaneous transluminal coronary angioplasty (PTCA), and coronary artery bypass graft surgery (CABG). Choice of procedure is determined by patient condition, location and extent of the ischaemia, staff and equipment resources, hospital protocols, and the personal bias of the attending physician. Regardless of the form, rapid diagnosis and intervention of the ischaemic event is crucial for effective early management.[1–7]

Several trials conducted in recent years indicate that appropriate application of thrombolysis significantly improves mortality rates; treatment within 6 hours of the onset of pain leads to an overall reduction in mortality of between 26 and 65 per 1000 patients, and this has been extensively documented.[5 7] Additionally, availability of the therapy within hospital emergency departments (EDs) makes thrombolysis a front line therapy for treatment of AMI.

Primary angioplasty

Primary PTCA performed punctually by skilled medical practitioners is the more beneficial therapy in certain circumstances, having a number of advantages over thrombolysis, including lower risk of haemorrhagic incident and improved conditions for coronary assessment.[8 9] Therefore, when time to in hospital treatment is short, such as occurs in a metropolitan area, PTCA should be the treatment of choice. Evidence also suggests that angioplasty after short acting thrombolytic therapy is the most beneficial, improving outcomes for AMI patients, particularly if there is a delay of more than

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Abbreviations: AMI, acute myocardial infarction; CABG, coronary artery bypass graft surgery; CAPTIM, Comparison of Angioplasty and Prehospital Thrombolysis In Acute Myocardial Infarction; ECG, electrocardiogram; ED, emergency department; GP, general practitioner; PTCA, percutaneous transluminal coronary angioplasty

1 hour before treatment of angioplasty, a common occurrence, particularly in rural areas.[9]

However, the cost of providing experienced staff and appropriate facilities make PTCA disadvantageous.[5] [9] In fact, in many pre-hospital environments and peripheral hospitals, angioplasty is unavailable and thrombolytic agents remain the most available and most effective intervention. This paper will therefore focus on the pre-hospital application of thrombolysis and its affect on survival post AMI.

Thrombolytic agents
AMI is the result of an occlusion to a coronary vessel or vessels. Thrombolytic therapy is aimed at lysis of the occlusion, removal of the obstruction, and restoration of blood flow to the ischaemic myocardium.[1–5] Thrombolytic agents eliminate the obstruction by activating the enzyme, plasmin, which in turn denatures fibrin, a protein binding the fibrous strands in blood clots.

Several different thrombolytic agents are available including streptokinase, tissue plasminogen activator alteplase, anistreplase, and urokinase. In the pre-hospital setting, newer more effective derivatives of alteplase, including reteplase and tenecteplase, are preferred, because they can be administered by single injection rather than infusion.[10] Moreover, with the newer drugs, the dosing pattern is standard irrespective of the body weight of the patient, making use simple in the pre-hospital setting.[11] These factors are important as they lead to decreased time to treatment, which is the most critical factor in reducing mortality rates.

The pharmacological action of thrombolytic agents is not limited to the site of the thrombus alone; activity extends throughout the vascular system, reducing thrombus formation and improving cerebral reperfusion.[12–14] However, a small percentage of those receiving therapy suffer a haemorrhagic incident. Benefit versus risk therefore needs to be carefully assessed on an individual basis.[13] [14]

Early reperfusion
Regardless of the agent used, thrombolysis is the therapy of choice for the treatment of AMI. Large scale trials provide evidence that early reperfusion therapy is extremely effective, with the greatest benefit gained from therapy within the first 3 hours. Mortality rates can be lowered by as much as 6.5% if treatment is given within the first hour, falling to 3.7% if within 2 hours and 2.6% after 6 hours.[7] Beyond 12 hours, thrombolytic therapy is no longer effective.

In the large TIMI-II trial, it was shown that for every hour that thrombolytic therapy is delayed, fatality rates rise 1%, with the most beneficial time being within the first hour after the onset of symptoms.[15] [16] In fact between 30% and 50% of patients with AMI fail to reperfuse when treatment is delayed for 90 minutes or more.[17] The prognosis of these patients is reduced, irrespective of age, sex, area of the myocardium involved, or the thrombolytic agent used.[5] In these cases percutaneous coronary intervention is used as a mode of "rescue".[17]

Thrombolytic therapy delays
Factors that negatively impact on time to reperfusion therapy are either patient or treatment related, and include delays caused by pre-hospital evaluation or treatment delays in the ED.[18]

Public education and perception of signs and symptoms of AMI are critical in reducing mortality rates. Remarkably, in industrially developed nations, only 50% of those with symptoms of AMI access the ambulance service. This figure is staggering considering the plethora of data indicating that ambulance assistance leads to a shorter time to definitive care because baseline examinations, history taking, and early interventions are initiated by pre-hospital ambulance

officers.[19] [20] While patient delay is a contributing factor, there are delays that can be directly affected by paramedics. One intervention that can be extremely effective in reducing time to treatment is 12 lead electrocardiography performed prior to arrival at the hospital.

12 lead electrocardiography
Acute coronary syndromes encompass a heterogenous group of patients with different clinical presentations, and differences in the extent and severity of underlying coronary atherosclerosis and degree of risk of progression to AMI.[21] For each patient, it is necessary for the pre-hospital practitioner to make rapid individual treatment decisions based on the history, examination, facilities and diagnostic equipment available, and transfer time to the nearest appropriate hospital. The recognition of AMI in the pre-hospital environment can be a difficult task. For example, silent AMI, in older patients, women, diabetics, and those taking non-steroidal analgesics, presents with breathing difficulty, heart failure, and neurological impairment as opposed to the more classic radiating or non-radiating retrosternal chest pain.[6] [7]

Electrocardiography is the key diagnostic tool to determine eligibility for acute reperfusion interventions. Because electrocardiography machines are portable and easy to use, there has been growing interest in their use in the pre-hospital setting. Although paramedics can obtain 12 lead electrocardiography readings reliably, pre-hospital electrocardiography is not routinely performed in many countries.[23] A study by Canto et al using a database of 275 000 from the National Registry of Myocardial Infarction showed that only 5% of patients receive field electrocardiography.[27]

Where ambulance service paramedics do use 12 lead electrocardiography to assist with early diagnosis of AMI, they achieve this in one of two ways. Either the 12 lead electrocardiogram (ECG) is transmitted to a doctor who makes a diagnosis (and may communicate this diagnosis back to the ambulance crew), or alternatively, ambulance paramedics are trained to interpret the ECG themselves. Transmission of an ECG requires technology at both ends of the transmission, a fault free line, the immediate availability of a senior doctor to make the diagnosis, and a system for communicating the diagnosis back to the ambulance crew. This system has a one in five chance of failure due to communication delays. Furthermore, such a system requires expensive, well maintained technology.[6] These problems are avoided if the paramedic can interpret the 12 lead ECG and recognise ST segment elevation.

Concerns have been raised over the accuracy and feasibility of 12 lead electrocardiography performance in the pre-hospital environment as well as the ability of paramedics to perform checklists safely and therapeutically.[28] The successful interpretation of the 12 lead electrocardiography by trained paramedics has now been documented in several studies.[22–33] For example, a 5 year study in Canada showed that paramedics can accurately identify patients who would have the greatest likelihood of benefiting from early, aggressive thrombolytic therapy.[33] Moreover, a study in the UK compared paramedics and cardiologists;[22] paramedics received two days intensive training in interpretation of a 12 lead ECG followed by consolidation in the field, after which time it was demonstrated that there was no significant difference between the two groups in recognition of ST segment elevation. As a result of this study, the need to transmit 12 lead electrocardiography results to hospitals for interpretation was negated.[22] A multitude of evidence now demonstrates beyond doubt that well trained paramedics can efficiently use 12 lead electrocardiography to provide early diagnosis and reduce delays.

The only controversy that remains is whether time to treatment is significantly affected when patients receive a 12 lead electrocardiography diagnostic intervention pre-hospital. While some authors express concerns regarding delays to treatment time associated with 12 lead electrocardiography use by paramedics, four independent studies have shown that while there may be an increase in time at the scene of between 4 and 10 minutes, on average the overall time to treatment is decreased.[29–32] Generally, the use of pre-hospital 12 lead electrocardiography appears to provide a multitude of benefits including deceased mortality, increased likelihood of receiving thrombolysis, increased likelihood of angioplasty, increased likelihood of CABG, and most importantly, decreased time to treatment.[27]

Pre-hospital reperfusion

Given that early thrombolytic therapy is highly desirable and that appropriately trained paramedics can effectively interpret 12 lead electrocardiography readings, the question then becomes: can appropriately skilled paramedics administer thrombolytic therapy in the pre-hospital setting, to further improve the chain of survival for patients with AMI? Several trials have been conducted to answer this question. Some trials have involved administration of thrombolytic agents by medical practitioners in the pre-hospital setting and others have compared the use of thrombolysis in the pre-hospital setting by paramedics and medical practitioners. In general, the outcomes were positive, and showed reduced mortality and reduced time to reperfusion as a result of early thrombolysis administration. In most cases, hospital delays were reduced by the transmission of 12 lead electrocardiography and or direct admission.[26 34–38]

Support for pre-hospital application of thrombolytic therapy has been provided by a study in Scotland, which showed that general practitioners (GPs) providing pre-hospital therapy affected mortality rates positively and that these continued to improve after discharge from hospital.[35] This study demonstrated that thrombolytic therapy can be safely administered outside of the hospital setting, can reduce treatment delays, and has significant beneficial outcomes.

A more recent analysis of mortality rates and pre-hospital thrombolysis administered by paramedics, intensive care paramedics and GPs showed the clear benefits of pre-hospital thrombolysis. A meta-analysis of six major randomised trials conducted by the American Heart Association, involving more than 6000 patients, demonstrated that thrombolytic treatment decreased time to treatment from the onset of symptoms by an average of 58 minutes (an average of 33 minutes in the urban areas and 130 minutes in rural areas). This led to a 17% reduction in relative risk in hospital mortality and an absolute risk reduction of 2%. which can be converted into one life saved per 62 patients treated in the pre-hospital setting.[34] This study also clearly demonstrated that neither drug type nor level of medical practitioner affected outcome.[34] Similarly a study in Victoria, Australia, showed that pre-hospital thrombolysis saves lives; calling for an ambulance rather than the GP has the greatest potential to save lives.[20]

Despite this and as a result of the Myocardial Infarct and Triage Intervention trial, the European Society of Cardiology and the European resuscitation council recommended pre-hospital thrombolysis be administered when times from the arrival at scene to hospital door are expected to exceed 30 minutes.[26] Even if physicians administer thrombolytic agents more effectively than appropriately trained paramedics,[17] there remains no doubt that delaying reperfusion of an ischaemic myocardium is fatal or affects quality of life. Thus, it may be time to advance the level of care given by ambulance service paramedics so that delays can be minimised.[39]

While thrombolysis administration by paramedics is advocated,[39] it is agreed that the administration of agents with fibrinolytic properties, particularly in uncontrolled environments, is a considerable responsibility. Although thrombolysis is an effective treatment strategy for both AMI and pulmonary embolism, clinical experience of this therapy, performed during resuscitation, has been limited owing to the anticipated risk of severe bleeding complications. The Thrombolysis in Cardiac Arrest study, one of the largest randomised, double blind, placebo controlled trials, is planned to assess the efficacy and safety of pre-hospital thrombolytic therapy in cardiac arrest of presumed cardiac origin.[40] The results of this study should clarify these issues and provide a clear framework for future therapeutic strategies.

CONCLUSION

Pre-hospital cardiac arrest has been associated with a very poor prognosis. AMI and massive pulmonary embolism are the underlying causes of out-of-hospital cardiac arrest in 50–70% of patients. Reducing the event to definitive treatment time should therefore be a priority, achieved through a multimodal strategy. The issues that need to be addressed include: education of the general public, access to emergency and healthcare systems, ambulance operations, paramedic training and education, and the interaction between in hospital and pre-hospital management.

Thrombolysis is an effective therapy that can result in reperfusion of ischaemic myocardium. The benefits of therapy are directly proportional to time from symptoms to administration, with most positive effects seen from administration within the first hour after onset of symptoms. There is evidence that supports the view that pre-hospital administration has benefits that clearly outweigh the risks particularly in areas of extended transport.

The polarised debate over the advantages of primary angioplasty verses thrombolysis has negatively impacted on implementation of thrombolysis for treatment of acute MI. In 2003,[41] the benefits of angioplasty over thrombolysis were championed, using data from the Comparison of Angioplasty and Prehospital Thrombolysis. In Acute Myocardial Infarction (CAPTIM) trial.[9] As a result, thrombolysis was not considered the "standard treatment" for acute MI. Moreover, a 3 hour delay to administration of thrombolysis in favour of transportation to an intervention centre was recommended.[41] This position was challenged by Lamfers and Verheught,[42] who pointed out that the CAPTIM trial data in fact negates the benefits of angioplasty over thrombolysis if all preparation, age, and time issues are taken into account. In fact, the CAPTIM trial strongly advocates the use of pre-hospital triage and early treatment.

Regardless of the position held in this argument, it is clear that thrombolysis remains a highly effective treatment strategy, particularly in areas that do not have ready access to a system of well developed intervention centres. It is in these cases particularly that treatment delays result in definitive care being compromised well beyond that useful for reperfusing compromised myocardial tissue.[43 44]

For those who have worked in the pre-hospital field, it is clear that the rapid identification and transport of patients with AMI has been and should be the focus of patient management. The data from a number of studies indicate that, at the very least, paramedics should be performing 12 lead electrocardiography in the field. This practice should be augmented by direct admission to an appropriate facility rather than standard ED admission.

With the advent of improved paramedic education and training and the release of new generation thrombolytic agents, more definitive care by trained paramedics is

advocated. The UK has become the frontrunner in the introduction of prehospital thrombolysis and 12 lead electrocardiography for paramedics, with active programmes underway across a number of services. The USA has also begun the implementation of 12 lead electrocardiography and thrombolysis in isolated services. Australia has one state service (the rural ambulance service of Victoria) conducting a trial for the effectiveness of pre hospital thrombolysis. Two other Australian states, New South Wales and Queensland, currently allow use of 12 lead electrocardiography by high level paramedics and are implementing trials of the technique by all paramedics in the field.

While the administration of pre-hospital thrombolysis to people with AMI remains a contentious issue, particularly if performed by paramedics, what cannot be argued is that early thrombolytic intervention reduces mortality and morbidity rates. Delays to this intervention are the greatest problem facing those with AMI; every minute of delay results in loss of expected longevity. A recent study in Portugal has again shown that pre-hospital intervention vastly improves outcome for AMI patients, particularly the elderly.[45]

The ambulance system and paramedics can directly and indirectly reduce these delays, and evidence to support implementation of advanced clinical practices in the field is currently being sought locally.

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