PREHOSPITAL CARE

Prehospital selection of patients for thrombolysis by paramedics

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Accepted for publication
12 December 2001
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Objective: Heart disease is the major cause of death in Wales. Myocardial infarction accounts for most fatalities either acutely or as a result of late heart failure and unheralded sudden cardiac death. Prompt relief of new coronary occlusions by thrombolytic agents has been shown to reduce significantly both early mortality and subsequent morbidity from acute myocardial infarction. The prehospital delivery of these drugs is feasible, and carries no greater risk than administration in hospital. This study tests the hypothesis that paramedics can identify patients with acute myocardial infarction who are suitable for prehospital thrombolysis, and thus reduce the "call to needle" time.

Method: Paramedics from rural Wales were trained in the acquisition and recognition of 12 lead ECGs, and also in the modified indications for thrombolytic therapy as defined by the Joint Royal Colleges Ambulance Liaison Committee (JRCALC). Ninety six consecutive patients, with possible myocardial infarction, were included in the study. The paramedics made an independent decision regarding the eligibility of the patients for thrombolysis before hospital admission, noting the time that they could have administered the drug. These decisions were compared with the treatment subsequently received in hospital.

Results: No errors were made by the paramedics in case selection (specificity of 100% (95% CI 95.9% to 100%)). There was a potential reduction in call to needle time of 41.2 minutes (95% CI 25.7 minutes to 56.9 minutes, p=0.001).

Conclusions: It was concluded that the paramedic selection of patients for the prehospital administration of a thrombolytic is both feasible and safe.

A strategy for the prehospital administration of thrombolytics by paramedics in the United Kingdom could potentially reduce delays to treatment and thereby improve survival of patients with acute myocardial infarction (AMI). The objective of this research was to test the hypothesis that the selection of patients for thrombolysis can be achieved accurately in a rural environment using criteria that have been established for this purpose by the Joint Royal Colleges Ambulance Liaison Committee (JRCALC).

METHOD

This was a prospective study involving a cohort of paramedics who undertook a specifically designed training course. The aim of the training was to enable the paramedics to identify those patients who would be suitable for prehospital thrombolysis.

Powys, a rural environment, was selected as the area in which the study would take place as transportation times of more than 30 minutes to the nearest district general hospital are frequently encountered. Paramedics who routinely work within the area were sent an informal letter inviting them to take part in the study

Ethics approval for the study was obtained from Dyfed Powys Health Authority.

Zoll Medical Corporation (Zoll Medical Corporation, Burlington, MA, USA) supplied six, M-series, CE197, manual defibrillators with 12 lead ECG capability, for use throughout the study. The machines had been configured to disable their diagnostic function.

Patients were considered for inclusion into the study only if the expected journey time to hospital was more than 15 minutes, and one or more of the following criteria were met

- Patients suffering chest pain believed to be cardiac in origin.
- Patients suffering chest pain of no obvious cause.

- Patients with ECG abnormalities not necessarily accompanied by chest pain, but who were apparently compromised as a result.
- Patients referred by a GP with a provisional diagnosis of a cardiac condition.

The indications and contraindications for thrombolysis used in this study were those recommended by JRCALC (table 1).

The indications were more restrictive and the contraindications wider than those used in hospital.

To facilitate the process for the paramedics, the contraindications and indications were formulated into a list of 20 questions. For thrombolysis to be indicated a *yes* had to be obtained to all the questions.

A training course was developed to educate the paramedics in the pathophysiology and clinical aspects of myocardial infarction, together with the benefits and side effects of thrombolytics. Instruction was given in the derivation, execution, and interpretation of the 12 lead ECG.

Having been called to a patient who satisfied the inclusion criteria for the trial, the paramedic immediately administered standard treatment having obtained an appropriate brief history, and then executed a 12 lead ECG. If the paramedic considered that thrombolysis was appropriate the *notional* time a thrombolytic would have been administered was recorded. When the paramedic identified an AMI (even if thrombolysis was not appropriate) the hospital was pre-alerted to gain any potential benefit from a reduction in the call to treatment time for the patient.

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Abbreviations: AMI, acute myocardial infarction, PPV, positive predictive value; NPV, negative predictive value

Table 1 JRCALC Indications/contraindications for prehospital thrombolysis

Contraindications to prehospital thrombolysis	Reduced level of consciousness (The patient must be able to give consent to thrombolytic therapy). Dementia (increased risk of stroke[1]). Age greater than 75 years (increased risk of stroke[2]). Continuous symptoms for less than 30 minutes or more than 6 hours (Myocardial salvage is limited beyond 6 hours[3]). Suspected aortic dissection (risk of severe bleeding). Pericarditis. Bradycardia of 50 beats per minute (bpm) or less (patient may require pacing). Tachycardia of 140 bpm or more (arrhythmia may be mimicking ECG changes synonymous with AMI). Systolic blood pressure (SBP) 80 mm Hg or less (risk of further hypotension if streptokinase administered). SBP 160 mm Hg or more (increased risk of stroke[4]). Pregnancy, or delivery within past two weeks (there are no data on fetal safety when thrombolytic therapy is administered during pregnancy, and there is also a risk of maternal bleeding in the first week postpartum). Peptic ulcer within the last 6 months (increased risk of bleeding). Previous stroke, or disability from a previous stroke (increased risk of stroke). Cerebral tumour (increased risk of bleeding). Active bleeding or known bleeding disorder (increased risk of severe bleeding). Recent blood loss, except for normal menstruation (menstrual bleeding that is not due to haematological abnormalities[5]). Anticoagulant therapy (risk of severe bleeding). Surgical operation, tooth extractions, significant trauma, or head injury within the past 4 weeks (increased risk of bleeding). Previous administration of streptokinase (antigenic and allergenic properties of streptokinase will reduce efficacy[6]). Chest compression for resuscitation for a period of longer than 5 minutes during the presenting incident (increased risk of bleeding due to traumatic injury). Liver failure, renal failure, or any other severe systemic illness (for example, chemotherapy for cancer) (increased risk of bleeding).
Indications to prehospital thrombolysis:	ST segment elevation of 2 mm or more (0.08s after the J point) in at least two standard leads or at least two contiguous precordial leads, not including V1. QRS width 0.14 mm or less, and bundle branch block absent from the tracing. NO atrio-ventricular block greater than 1st degree (if necessary after treatment with intravenous atropine).

Data were collected by the author, and entered into a Microsoft Access database (Microsoft Access 97, Microsoft Corporation, USA). Where possible, the treatment notes for all the patients included in the study were examined to ascertain if, and at what time, the patient underwent thrombolytic therapy. Alternative methods were used to obtain the relevant information where notes could not be traced. These included contacting the patients' own general practitioner or consultant, or examining accident and emergency admission forms.

It was recognised in the design of this study that the indications for hospital thrombolysis and the indications for prehospital thrombolysis following the JRCALC criteria were different. It was therefore to be expected that there would be some discrepancies between the prehospital paramedic decision and the final treatment outcome of the patient. Where a discrepancy occurred two cardiologists and the author reviewed copies of the 12 lead ECG traces and the patients' details to decide whether the discrepancies depended only on the different hospital and prehospital indications, or whether there were any errors.

The sample size calculation was based on an estimated acceptable level of specificity of the paramedics' ability to select patients for prehospital thrombolysis, 98% (95% confidence intervals (CI) of +/-3%). This equated to a total sample size (N) of 96 patients. The specificity was considered

in preference to the sensitivity for this calculation because of the necessity to keep the number of false positives to a minimum.

The sensitivity, specificity positive predictive value (PPV), and negative predictive value (NPV) for the paramedic selection of patients for thrombolysis were calculated.

Student's *t* test was used to analyse the difference between the mean of the actual "call to needle" time and the mean of the *notional* "call to needle" time. Data were analysed using the statistical software package; SPSS version 9 (SPSS, Inc, Chicago, IL, USA). An SPSS single proportion macro was used to calculate the 95% CI for the sensitivity, specificity, NPV and PPV.[7]

RESULTS

Sixty per cent (24 of 40) of the paramedics agreed to take part in the study, and underwent training. Of these, 79% (19 of 24) paramedics were responsible for including patients into the study.

Complete data were available for 95 of the 96 patients included in the study. Patient characteristics are shown in table 2.

As can be seen from tables 3 and 4 there were no false positive decisions made by the paramedics. Table 5 gives details of

Table 2 Summary statistics for all patients in the study

Sex	Number (%)	Mean age/years (SD)	95% Confidence intervals/years
Male	63 (65.6)	62.4 (12.4)	59.2 to 65.5
Female	33 (34.4)	68.3 (12.3)	63.9 to 72.6
Total patient group	96 (100)	64.4 (12.6)	61.8 to 66.9

Table 3 Paramedic decision compared with inhospital decision for thrombolysis

	Actual thrombolysis in hospital		
	Yes	No	Total
Paramedic decision to thrombolyse			
Yes	7	0	7
No	8	81	89
Total	15	81	96

Table 4 Probabilities associated with the paramedics' ability to select patients for thrombolysis

	Proportion	Point estimate/%	95% CI/%
Sensitivity	7/15	46.7	24.8 to 69.9
Specificity	81/81	100	95.5 to 100
Positive predictive value (PPV)	7/7	100	64.6 to 100
Negative predictive value (NPV)	81/89	91.0	83.3 to 95.4

the eight patients for whom there was a discordant decision between the prehospital and the inhospital decision The results show that all the discrepancies were attributable to differences in the prehospital and inhospital inclusion criteria, and not attributable to error. Tables 6 and 7 show the revised results obtained by comparing the paramedics' decision for prehospital thrombolysis with a "hypothetical" decision made by the hospital based physicians as to the suitability of the patient for *prehospital* thrombolysis.

Table 8 shows the mean *notional* and actual "call to needle" times. There is a significant difference of 41.2 minutes (p=0.001) for the seven patients for whom the paramedics decided that prehospital thrombolysis would have been appropriate.

DISCUSSION

This study shows that the paramedics were able accurately to select those patients eligible for prehospital thrombolysis according to the current criteria. Discrepancies were found between the prehospital decision made by the paramedics and the final inhospital decision to treat the patient with a thrombolytic. This was anticipated given the stringent inclusion criteria for prehospital thrombolysis imposed upon the paramedics for reasons of safety. In addition a number of patients who were ultimately eligible for thrombolytic therapy might not present the necessary ECG criteria in the early stages of the infarct because of the cyclic variations in ST segments in early infarction.[8] However, none of the discrepancies were found to be attributable to erroneous decisions on behalf of the paramedics.

Table 6 Contingency table comparing the paramedics' decision with the hospital based physicians' hypothetical decision for prehospital thrombolysis

	Adjusted hospital based physicians' decision		
	Yes	No	Total
Paramedic prehospital decision			
Yes	7	0	7
No	0	89	89
Total	7	89	96

It should be noted that the significance of the results of this study are based upon the *specificity* of the paramedic decision for which the confidence interval is within acceptable parameters. The wide confidence interval around the *sensitivity* of the paramedic decision is attributable to the relatively small numbers of patients included in the study coupled with the low prevalence of patients eligible for thrombolysis, but the study design reflected less concern with the possible omission of treatment than with the risk of inappropriate treatment.

There is a significant reduction in the delay to treatment when comparison is made between the time the patients called for help to the time the paramedics made the decision to thrombolyse (notional call to needle time) and the actual time taken before treatment was administered. But again, the problem of small sample sizes means the confidence intervals

Table 5 Review of paramedic decision for patients where discrepancy exists

Contraindications present to prehospital thrombolysis (as judged by paramedics)	ECG criteria for prehospital thrombolysis present (as judged by expert panel)	ECG criteria correctly identified by paramedic	Correct paramedic decision for prehospital thrombolysis
Breathing influenced pain Systolic BP >160 mm Hg No ST elevation	No	Yes	Yes
Continuous symptoms started >6 h ago No ST elevation Possibility of streptokinase previously given	No	Yes	Yes
Systolic BP >160 mm Hg No ST elevation QRS complex wider than 0.14 seconds	No	Yes	Yes
Systolic BP >160 mm Hg Suspicion of peptic ulcer	Yes	Yes	Yes
Systolic BP >160 mm Hg	Yes	Yes	Yes
Systolic BP >160 mm Hg	Yes	Yes	Yes
Pulse <50 bpm	Yes	Yes	Yes
Continuous symptoms started >6 h ago No ST elevation QRS complex wider than 0.14 seconds	Yes	No	Yes

Table 7 Adjusted probabilities for the paramedic selection of patients suitable for prehospital thrombolysis

	Proportion	Point estimate/%	95% CI/%
Sensitivity	7/7	100	64.6 to 100
Specificity	89/89	100	95.9 to 100
Positive predictive value (PPV)	7/7	100	64.6 to 100
Negative predictive value (NPV)	89/89	100	95.9 to 100

Table 8 "Call to needle" times

	Number in sample	Mean/min (SD)	95% CI /min
Actual call to needle time (total sample)	14	131.5 (108.9)	68.6 to 194.4
Notional call to needle time	7	41.9 (25.8)	18.0 to 65.9
Call to needle times for subset of patients where both actual and notional call to needle times exist	7	83.1 (21.66)	63.1 to 103.2

are very wide. A mean point estimate of a potential saving in time to thrombolysis of 41minutes is likely to carry considerable clinical benefit. Using data from the GREAT study, Rawles has calculated that every minute of delay costs on average 10 days of life for patients treated in the first three hours of infarction.[9] This could equate to an extra 450 days of life for those patients thrombolysed within three hours of the onset of pain.

The results show that this cohort of paramedics who agreed to participate in this study could select patients for prehospital thrombolysis with a high degree of accuracy. However, it is probable that the most pre-active paramedics were those who agreed to undergo the training and actively participated in the study, which is a potential limitation to the generalisability of these results. In addition there is the possibility of some unintended patient selection bias within this study population. The paramedics who contributed most to the study are predominantly based at three stations. Although there is constant movement of ambulances within Powys the general trend is for crews to attend the calls that are closest to their base station. This may have introduced a selection bias because of the geographical restriction of the study population.

Any strategy to reduce the delay to thrombolysis that may be adopted by Ambulance Trusts may well be dependent on the resources available and the opportunity costs that may be incurred. A minimum requirement will be a level of extended training in 12 lead ECG interpretation. Defibrillators with 12 lead ECG capability that may or may not have decision support software, or telemetric capability may need to be purchased. Consideration must also be given to the proximity of definitive care. For treatments that are so time dependent as thrombolytic therapy, "definitive care" ought not to be thought of a department within a hospital, but the actual administration of the thrombolytic. The clock does not stop at the hospital door. Although some have advocated prehospital thrombolysis for rural areas where long journey times are likely,[10] the possibility must also be considered that benefit may well be lost if a short journey to an urban hospital is followed by a long wait for treatment.

The early identification by paramedics of patients who are suitable for thrombolysis has the potential to contribute to the reduction of the "call to needle" time for patients suffering from AMI. Having identified a patient, the paramedic can, at least, pre-alert the receiving hospital, and at most, facilitate the delivery of a thrombolytic drug in the prehospital environment.

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