Pre-hospital treatment of STEMI patients

A scientific statement of the Working Group Acute Cardiac Care of the European Society of Cardiology

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Introduction

Optimal treatment for ST-elevation myocardial infarction (STEMI) is based on a reperfusion strategy employing either primary percutaneous coronary intervention (PPCI) or thrombolytic therapy (TT). A sizable proportion of STEMI patients are not reperfused, time delays are frequently unacceptable[1] and very few patients receive all the guideline-recommended therapies in a timely manner. Decision-making in the pre-hospital setting is pivotal for optimal STEMI care, and delays in therapy cannot later be compensated. Thus, the empowerment of paramedical staff is key to successful pre-hospital STEMI management. This requires the implementation of systems of care (STEMI networks), in which the Emergency Medical Service (EMS), non-PCI-capable hospitals, and hospitals with PCI facilities cooperate closely in order to reduce the total ischaemic time, increase the number of patients receiving reperfusion therapy, and to reduce heart failure and mortality [2] .

Delays

The total ischaemic time (Figure 1) is often unacceptably long with only 11-15% patients treated within the recommended time intervals. [3]

Patient delay. An early first call to the EMS is desirable as rapid diagnosis and treatment at the scene has been shown to save lives and prevent complications. The patient's decision time (PDT) has historically remained constant at between 1-3 hours. Patients with longer PDTs tend to be older, female and diabetic, with atypical symptoms. There is significant variation in the use of EMS in STEMI (28-82% patients) and in the PDTs (81-174 mins) throughout Europe. While several public initiatives have been successful in shortening PDTs, such campaigns have only a temporary impact.

An integral part of the EMS is triage by the emergency medical dispatcher. First medical contact is defined as the time at which STEMI diagnosis is made using ECG, irrespective of the setting.

Pre-hospital organisation. Not all patients referred for PPCI receive optimal percutaneous reperfusion (i.e. PCI performed in a timely manner by an experienced team), and even in urban locations a minority still require pre-hospital thrombolysis (PH-T)[4]. Geographical considerations and distribution of PPCI centres are two factors that contribute to the variability in European rates (5-92%).[5] The best evidence for reperfusion

strategies is based on in-hospital STEMI studies, and more high-quality research on the pre-hospital environment is needed. The key to diagnosis is the pre-hospital electrocardiogram (PH-ECG)[6], interpreted on site and/or transmitted for interpretation

Pre-hospital ECG

The use of the PH-ECG is widespread in some countries and has been shown to reduce the time to reperfusion and mortality in patients with STEMI. Trained paramedics can identify STEMI with a good sensitivity and specificity, with multiple studies demonstrating that PH-ECGs decrease door-to-needle (D2N) and door-to-balloon (D2B) times.[7]

Reperfusion strategies

PH-T significantly reduces reperfusion time when compared with awaiting IH-T, increases the odds of aborted MI and improves outcome[8]. The advantages of integrating TT and PCI have been demonstrated in several studies, and in order to facilitate this, networks for STEMI management should be developed on a national and/or regional level, with continued measurement of outcome and quality metrics.

Registries and STEMI networks: organization and outcome in practice

STEMI mortality reported in registries is higher than in randomized clinical trials (RCTs). As the results of RCTs may only be applicable to 50% of patients in clinical practice, registry data may provide additional information, including the challenges in implementing RCT-derived recommendations. As shown from registry data, an increase in the PPCI-related delay (D2B minus D2N time) is associated with higher mortality rates. The time point at which PPCI loses its survival advantage over fibrinolysis varies considerably between subgroups, from <1 hour to 3 hours[9]. Registry data also show that field transfer is faster than inter-hospital transfer, resulting in more patients achieving a D2B time $\leq$ 90mins. The main findings[10-13] of selected European registries on pre-hospital STEMI care are shown in Table 1.

Pre-hospital adjuvant therapies

Several recommendations have been made to attempt to standardise care and reduce major adverse cardiac

events (MACE) and mortality in pre-hospital STEMI management (Table 2). Some drugs effective for in-hospital STEMI treatment are not indicated (GP IIb/IIIa inhibitors) or are lacking data in the pre-hospital setting (prasugrel, bivalirudin).

Pre-hospital management of STEMI complications

Timely and appropriate pre-hospital management can stabilise the patient, enabling safe transportation to the most appropriate hospital for more definite treatment.

Cardiac arrest. The highest proportion of deaths due to MI occur early during the pre-hospital phase, before any medical support is at hand. The commonest cause is ventricular fibrillation, induced by ischaemia and reperfusion. In patients with no return of spontaneous circulation (ROSC), TT does not improve survival[14]. PPCI is an alternative for reperfusion in survivors of out-of-hospital cardiac arrest, and may be an independent predictor of survival.[15]

Therapeutic hypothermia should be part of the standardised treatment strategy for comatose survivors of cardiac arrest.

Cardiac arrhythmias. Arrhythmias are associated with increased mortality in acute coronary syndromes (ACS). Basic and advanced life-support algorithms and defibrillation/cardioversion should be applied where indicated. Beta-blockers and amiodarone may be considered in case of ventricular tachyarrhythmias; alternative drugs are class 1A/1B antiarrhythmics.

Acute bradycardia due to STEMI. Complete heart block during STEMI is associated with a high mortality rate. Severe bradycardia and high-grade atrio-ventricular block may be reversed by i.v. atropine sulfate in inferior or posterior acute myocardial infarction (AMI), while in anterior AMI emergency pacing may be required.

Pulmonary oedema. Heart failure during STEMI is associated with poor short- and long-term prognosis, and PPCI is preferred in STEMI complicated by pulmonary oedema. Minor degrees of pulmonary oedema often respond to nitrates and diuretics, and in the absence of hypotension, i.v. nitroglycerine should be administered except in the presence of right ventricular infarction. Oxygen should be administered to patients with breathlessness and/or clinical signs of heart failure and/or cardiogenic shock (CS), and continuous positive airway pressure or endotracheal intubation with ventilatory support may be required.[16]

Morphine should be used only when clinically indicated.

Cardiogenic shock. CS complicates AMI in 2.8-11% of cases, with a median time from AMI onset of 6.2 hours, and a mortality rate > 50%. PPCI is the preferred option in patients with CS and high-risk features,[17] with TT where PPCI is likely to be delayed. Early diagnosis and treatment of established and developing CS is paramount. Here patients should be transported to PCI- and intra-aortic balloon pump-capable hospitals. Pre-hospital treatment of CS includes volume administration (in the absence of pulmonary oedema), oxygen (to achieve O_2 saturation > 95%), and inotropic support (dobutamine and dopamine) if the systolic blood pressure is <90 mmHg. In such cases, a low threshold for intubation and mechanical ventilation exists.

Right ventricular infarction.This should be suspected where the clinical picture is of hypotension, clear lung fields and a raised jugular venous pressure in a patient with an inferior STEMI. ST-segment elevation in V_4R is also suggestive. Right ventricular preload should be maintained and vasodilators avoided. Although limited fluid expansion is effective in many cases, additional inotropic support may be required. PPCI is the preferred therapeutic option, with TT where PPCI is likely to be delayed.

Education

The educational challenges for improved pre-hospital care are considerable, ranging from EMS personnel to hospital-based cardiologists, nurses and other paramedical staff, funding bodies, policy makers and planners of health care.

EMS systems vary in their approach to receiving and prioritising emergency calls, ranging from a physician to computerised priority dispatch algorithms. EMS models can be dichotomised as the Franco-German model (physicians in the control room and in ambulances), or the Anglo-American mode (paramedics/emergency medical technician-staffed ambulances, working to agreed protocols, supported by physician direction and/or telemedicine). The duration of training and degree of autonomy varies widely between programmes.

The knowledge, skills and behaviours outlined in the ACS section of the ESC Core Curriculum for the general cardiologist could be expected to apply, in various degrees, to all professionals engaged in pre-hospital STEMI care. Education of EMS staff in clinical research is of value, to facilitate safe and ethical recruitment to approved, well-designed studies.

Training

The need for a medical specialty. Emergency medicine (EM) is the medical specialty with the principal mission of evaluating, managing, treating and preventing unexpected illness and injury. It is a practice in which time is critical. The second EuSEM Core Curriculum for emergency medicine stated a minimum of 5 years in a recognised training program for EM specialists.[18]

The need for a cardiological sub-specialty. Patients admitted to the Intensive Cardiac Care Units (ICCUs) are increasingly older, have more severe cardiac conditions and associated comorbidities, with more than 50% having important co-morbidities. To deliver optimal treatment to this patient population requires cardiologists to have full knowledge of the range of techniques and procedures required in intensive acute cardiac care (IACC).[19] Cardiologists working in ICCUs must therefore adapt their knowledge and abilities to these new demands. The process of certification in IACC should standardise training in the specialty and facilitate delivery of state-of-the-art treatment to patients admitted to ICCUs in Europe.[20]

Summary and conclusions

The pre-hospital phase is the most critical in STEMI treatment. Minimising patient-related delay is the first key step in STEMI treatment: public/patient education campaigns, community organisation, and the presence of an unique European-wide emergency telephone number may be advisable. The availability of automated external defibrillators (AEDs) in public places may be of value. The ambulance service has a pivotal role in STEMI management and cardiac arrest. All emergency ambulances should be equipped with defibrillators, 12-lead electrocardiographs and staffed with at least one person proficient in advanced cardiac life support. ECG transmission/ teleconsultation may be useful.

Implementation of systems of care has a pivotal role in modern STEMI treatment, based on networks among medical and cardiology institutions of different technological levels, connected by an effective EMS. There are two main models of transfer; the hub-and-spoke transfer system and the STEMI receiving centre (SRC). In the first model, patients presenting to a non-PCI capable hospital are either treated with TT or immediately transferred for PPCI. In the second model, non-SRC are bypassed by transport systems, delivering patients directly to an experienced PPCI centre. An additional option has been proposed with

experienced interventionalists undertaking PPCI in peripheral catheter laboratories. PPCI is the preferred treatment option for STEMI when performed within guideline times, with the maximal acceptable PPCI-related delay <120 min (<90 min for young early presenters)[7]. Where PH-T is performed, this results in a reduction of 15-20% in early mortality, when compared with IH-T, and the combination of PH-T with early (but not immediate) coronary angiography and PCI further improves patients' outcome. Appropriately educated and motivated healthcare professionals are central to overcoming existing barriers to provide optimal patient care. Scientific societies have a critical role in promoting research and guideline implementation, whilst taking into account the the economic imbalances, and diversity of healthcare systems amongst the European countries.[5] Finally, adequate involvement of political and administrative bodies is mandatory.

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Legend Figure 1

Components of total delay to reperfusion in patients with STEMI. Redrawn after Fox & Huber.[2]

FMC = first medical contact; D2N (door-to-needle) = interval between FMC and the start of fibrinolytic drug administration; D2B (door-to-balloon) = interval between FMC and infarct-related artery (IRA) reopening (by guidewire placement, thrombus aspiration or balloon inflation, whichever comes first). For the other abbreviations, see text.

Table 1 - European Registries on pre-hospital STEMI care

name	country	primary end-point	results
Royal Victoria Hospital	United Kingdom	PHT vs IHT	↓ call to thrombolysis time ↓ mortality
USIC	France	PHT + PCI	↓ mortality with PHT + PCI, in comparison with IHT, PPCI and non-reperfused pts
FAST-MI	France	PHT+PCI vs PPCI	comparable results
RISK-HIA	Sweden	PHT vs IHT vs PPCI	PPCI had the lowest mortality, followed by PHT and then by IHT
MINAP	United Kingdom	Reinfarction following PHT	The lag phase between UFH bolus and start of infusion is critical for outcome
Vienna	Austria	Implementation of a STEMI city system of care (cath-lab rotation, PHT)	vs. pre-implementation period: ↑ % reperfused pts ↓ mortality
Bologna	Italy	Implementation of a STEMI provincial tiered system of care (PHT+PCI, PPCI)	vs. pre-implementation period: ↑ % PPCI, ↓ % TT, ↑ % reperfused pts ↓ in-hospital and long-term mortality
NORDISTEMI *	Norway	TT (57% PHT) + immediate routine vs later selective transfer	↓ MACE

* randomized clinical trial; pts = patients; ↑ = increase; ↓ = decrease; for other abbreviations, see text

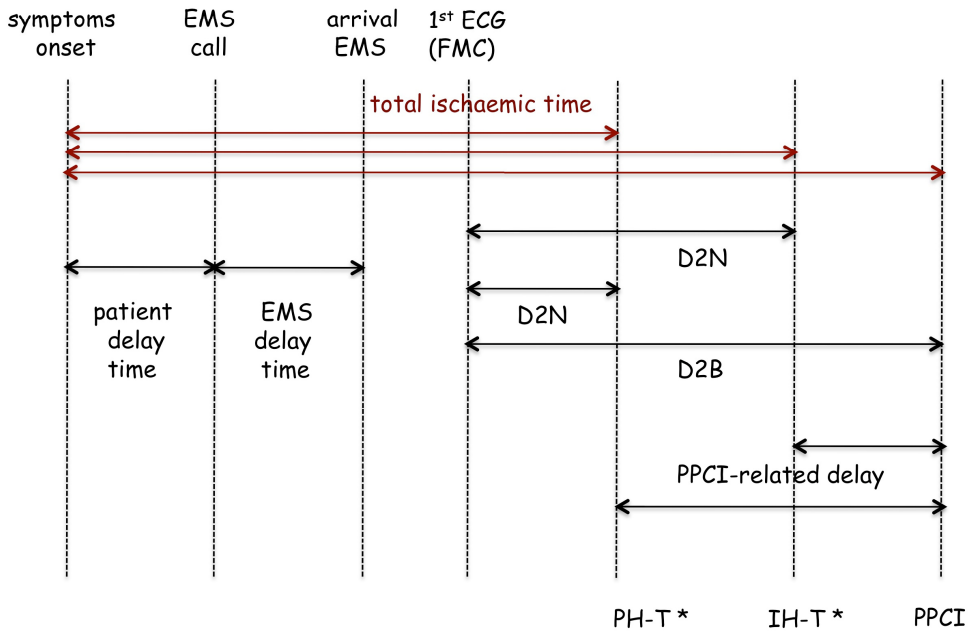
Table 2 – Pre-hospital adjuvant antithrombotic therapies

drug	dose	indication
aspirin	150 mg p.o. * 250-500 mg e.v.**	all STEMI pts
clopidogrel	300 mg p.o. 600 mg p.o. # 75 mg p.o.	PPCI and TT in pts ≤ 75 yrs advisable in PPCI TT in pts > 75 yrs
UFH	100 U/kg iv bolus 60 U/kg (max 4000 U) iv bolus + 12 U/kg/h (max 1000 U/h) iv infusion	PPCI TT and in non reperfusion Rx pts
enoxaparin	30 mg iv bolus + 1 mg/kg/12 h (max 1000 U/12 h) no bolus + 0.75 mg/kg/12 h (max 75 mg/12 h) doses every 24 hrs	TT and in non reperfusion Rx pts TT pts > 75 yrs pts with CrCl < 30 ml/min
fondaparinux §	2.5 mg sc bolus + 2.5 mg sc qd	TT and in non reperfusion Rx pts

* non-enteric coated formulation, chewed; ** when oral ingestion is not possible; # off-label dosage;

§ contraindicated in pts with CrCl < 20 ml/min; pts = patients; Rx = therapy; CrCl= creatinine clearance;

for the other abbreviations, see text.



* after delivery of reperfusion therapy, a "reperfusion therapy to coronary recanalization" time should be considered

ACS	Acute coronary syndromes
AED	automated external defibrillator
AMI	acute myocardial infarction
CS	cardiogenic shock
D2B	door-to-balloon time
D2N	door-to-needle time
EM	emergency medicine
EMS	emergency medical service
IACC	intensive acute cardiac care
ICCU	intensive cardiac care unit
IH-T	in-hospital thrombolysis
MACE	major adverse cardiac events
NSTEMI	non-ST elevation myocardial infarction
PDT	patient's decision time
PH-ECG	pre-hospital electrocardiogram
PH-T	pre-hospital thrombolysis
PCI	percutaneous coronary intervention
PPCI	primary percutaneous coronary intervention
RCTs	randomised clinical trials
ROSC	return of spontaneous circulation
SRC	STEMI receiving centre
STEMI	ST elevation myocardial infarction
TT	thrombolytic therapy.