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How to set up regional STEMI networks: a "Stent – Save a life!" initiative

Alfonsina Candiello[1], MD; Thomas Alexander[2], MD; Rhena Delport[3], MSc, PhD; Gabor G. Toth[4], MD, PhD; Paul Ong[5], MD; Adriaan Snyders[6], MD; Jorge A. Belardi[1], MD; Michael K.Y. Lee[8], MD; Helder Pereira[9], MD; Awad Mohamed[10], MD, MSc; Jorge Mayol[11], MD; Jan J. Piek[12], MD, PhD; William Wijns[13], MD, PhD; Andreas Baumbach[14], MD, PhD; Christoph Naber[15]*, MD, PhD

1. Instituto Cardiovascular de Buenos Aires, Buenos Aires, Argentina; 2. Kovai Medical Center, Coimbatore, India; 3. Department of Family Medicine, School of Medicine, University of Pretoria, Pretoria, South Africa; 4. University Heart Center Graz, Division of Cardiology, Department of Medicine, Medical University Graz, Graz, Austria; 5. Tan Tock Seng Hospital, Singapore, Singapore; 6. Wilgers Hospital, Pretoria, Gauteng, South Africa; 8. Division of Cardiology, Queen Elizabeth Hospital, Kowloon, Hong Kong, China; 9. Hospital Garcia de Orta, Almada, Portugal; 10. Department of Medicine, University of Khartoum, Khartoum, Sudan; 11. Centro Cardiológico Americano, Montevideo, Uruguay; 12. Amsterdam UMC, University of Amsterdam, Heart Center, Department of Clinical and Experimental Cardiology, Amsterdam Cardiovascular Sciences, Amsterdam, the Netherlands; 13. The Lambe Institute for Translational Medicine and CÚRAM, National University of Ireland Galway, Galway, Ireland; 14. Department of Cardiology, Barts Heart Centre, Barts Health NHS Trust, London, United Kingdom; 15. Klinikum Wilhelmshaven, Wilhelmshaven, Germany

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KEYWORDS

- adjunctive pharmacotherapy
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- STEMI

Abstract

Clinical guidelines recommend the development of ST-elevation myocardial infarction (STEMI) networks at community, regional and/or national level to ideally offer primary coronary angioplasty, or at least the best available STEMI care to all patients. However, there is a discrepancy between this clinical recommendation and daily practice, with no coordinated care for STEMI patients in many regions of the world. While this can be a consequence of lack of resources, in reality it is more frequently a lack of organisational power. In this paper, the Stent - Save a Life! Initiative (www.stentsavealife.com) proposes a practical methodology to set up a STEMI network effectively in any region of the world with existing resources, and to develop the STEMI network continuously once it has been established.

Corresponding author: Department of Medicine I, Klinikum Wilhelmshaven, Friedrich-Paffrath-Str. 100, 26389 Wilhelmshaven, Germany. E-mail: christophk.naber@gmail.com

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Abbreviations

ACC/AHA	American College of Cardiology/American Heart Association
cath lab	cardiac catheterisation laboratory
EMS	emergency medical services
ESC	European Society of Cardiology
FMC	first medical contact
GP/GC	general practitioner/general cardiologist
LMIC	low- and middle-income countries
PI	pharmacoinvasive
PCI	percutaneous coronary intervention
pPCI	primary percutaneous coronary intervention
SSL	Stent – Save a Life!
STEMI	ST-elevation myocardial infarction
TIT	total ischaemic time

Introduction

Primary percutaneous coronary intervention (pPCI) is the preferred reperfusion therapy for patients presenting with ST-elevation myocardial infarction (STEMI), as recommended by clinical guidelines[1]. pPCI is clearly superior to all other treatments investigated to date regarding mortality and morbidity and, in addition, is cost saving for national economies[2]. All healthcare systems should aim to provide pPCI to all STEMI patients, independent of location, nationality, race, sex or personal wealth. As a first step, available resources should be organised to provide the best available care to all patients and to optimise STEMI management nationwide. To reach this goal, systems of care for STEMI management need to be developed at a community, regional and/or national level[3-5]. This document proposes a universal methodology to provide the best available, guideline-adherent care for STEMI patients based on five general assumptions **(Table 1)**.

REVIEW OF CLINICAL GUIDELINES

THERAPEUTIC OPTIONS

Reperfusion of the myocardium by pPCI within 12 hours of symptom onset is the cornerstone of STEMI treatment, followed by a pharmacoinvasive strategy (PI) if pPCI cannot be performed within 120 minutes of diagnosis, or, if the latter is also not available, stand-alone fibrinolysis. In any PI or lysis strategy, patients should be transferred urgently to a percutaneous coronary intervention (PCI) centre after lysis[1,6-8].

CHOICE AND TIMING OF THE OPTIMAL THERAPY

As a first step, all healthcare systems should develop regional networks of care for STEMI patients to counter regional disparities as much as possible[9]. Until timely pPCI can be provided to all patients, the preferred reperfusion strategy for each patient will depend on local resources, timing, and the entry point into the network **(Figure 1, Table 2, Supplementary Table 1)**.

CHARACTERISTICS, ELEMENTS AND ROLES IN A STEMI NETWORK

Only an effectively organised STEMI network will ensure that all STEMI patients will be optimally treated within the window of opportunity. All resources and processes in a region should be organised to serve this single purpose.

MAIN CHARACTERISTICS OF A STEMI NETWORK

- 24/7 treatment service for all STEMI patients
- structured cooperation among all parties involved following standardised protocols
- regular structured meetings and continuous education of all parties involved
- continuous self-assessment and improvement of the network.

MAIN PLAYERS IN A STEMI NETWORK

Patients

Ideally patients should be able to recognise symptoms of myocardial infarction and understand the importance of receiving urgent treatment. They should understand how to activate the emergency medical services (EMS) or otherwise seek immediate medical attention **(Supplementary Table 2)**.

General practitioner/general cardiologist (GP/GC)

GPs/GCs play an important role as first responders to patient consultations. GPs/GCs should be integrated into a STEMI network and should be able to recognise and manage patients with STEMI according to standardised protocols **(Supplementary Table 2)**.

Emergency medical services

EMS are important coordinators of the referral pathway[3,10]. Their main actions entail pre-hospital patient management and between-hospital transfers. An EMS should always coordinate its actions with the network and notify the receiving hospital prior to arrival to check capacities and allow preparation. Ideally, all EMS should be centralised and activated through a single and well-publicised dispatch telephone number[1] **(Supplementary Figure 1, Supplementary Table 2)**.

Table 1. Key factors for any STEMI network.

Factor	Assumption
Players	The relevant stakeholders in any STEMI network are: patient and family, GP/GC, EMS, non-pPCI hospital, and pPCI-hospital.
Roles	The roles of the players are defined by i) evidence-based clinical guidance, and ii) the presence or absence of other players.
Scenarios	The existing players and their roles determine the number of possible scenarios for any network.
Treatment options	A given scenario always defines the best available therapeutic option in a region for STEMI patients.
Quality metrics	Continuous monitoring and feedback is key to improving the network.

EMS: emergency medical services; GP/GC: general practitioner/general cardiologist; pPCI: primary percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction

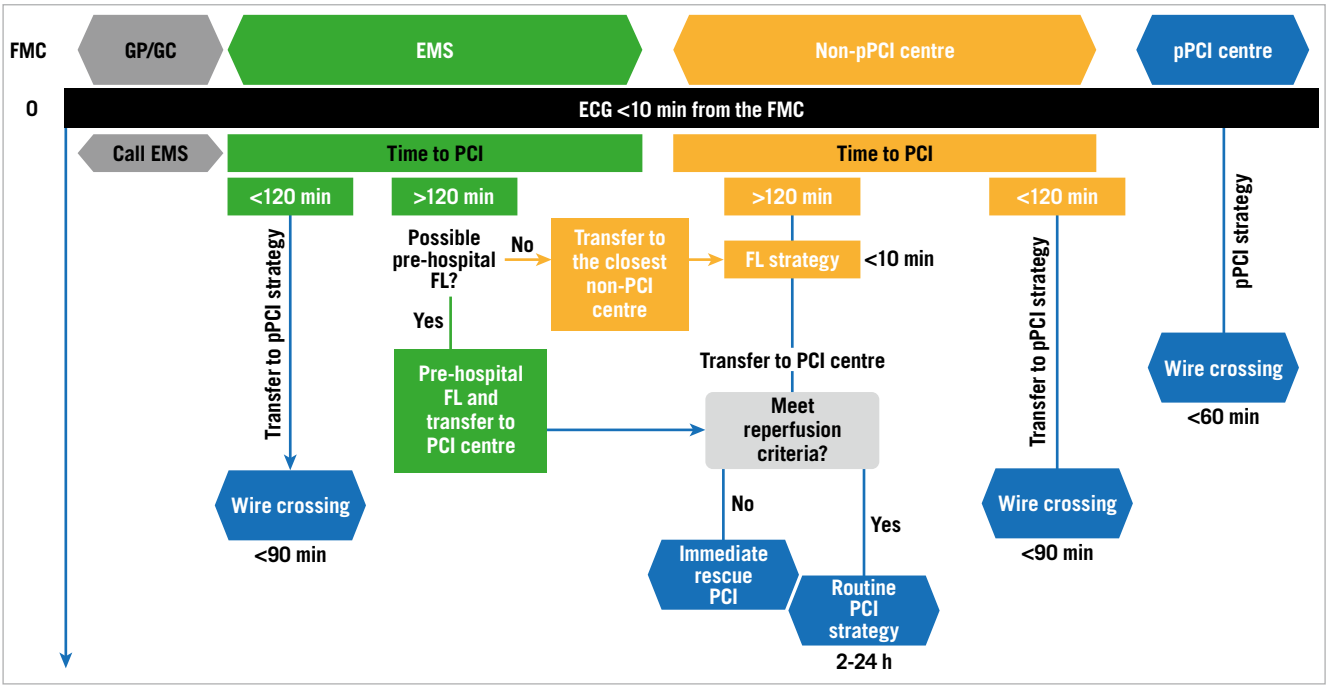


Figure 1. *Recommended reperfusion strategies according to timing and point of entry to the network. ECG: electrocardiogram; EMS: emergency medical services; FL: fibrinolysis; FMC: first medical contact; GP/GC: general practitioner/general cardiologist; min: minutes; PCI: percutaneous coronary intervention; pPCI: primary percutaneous coronary intervention*

Table 2. Definition of important time points and intervals in STEMI networks.

Time period	Abbreviation	Definition
First medical contact	FMC	Time point when the patient is initially assessed by a physician, paramedic, nurse or trained EMS personnel who can obtain and interpret the ECG and deliver initial interventions. FMC can be in the pre-hospital setting or upon arrival at the hospital. In all scenarios, STEMI diagnosis via ECG should be obtained within 10 minutes.
Time of reperfusion	TOR	The time point of either a wire crossing the occlusion or the start of administration of lytic therapy.
Total ischaemic time	TIT	The time from symptom onset until reperfusion is a strong predictor of patient outcomes. TIT comprises patient delay and system delay.
Patient delay	PD	Time interval between symptom onset and FMC.
System delay	SD	Time interval between FMC and time of reperfusion.
Door-in-door-out time	DIDO	Time between patient arrival in a non-pPCI centre and the transfer to a pPCI centre.

ECG: electrocardiogram; EMS: emergency medical services; pPCI: primary percutaneous coronary intervention; STEMI: ST-segment elevation infarction

Non-pPCI centres and hospitals without PCI facilities

These centres receive STEMI patients through two different pathways – directly from home or the community, or via transfer by EMS. Non-pPCI centres should diagnose a STEMI within 10 minutes after the patient's arrival and perform pPCI or transfer to a pPCI centre, or handle a PI strategy **(Supplementary Figure 2, Supplementary Table 2)**.

Primary PCI centres

pPCI centres receive STEMI patients through one of three pathways – directly from home or the community, via transfer by EMS, or by secondary transportation from a non-pPCI centre. They should have a mandatory 24/7 cath lab available within 30 minutes of activation. They are obliged to operate a "non-refusal" admission policy **(Supplementary Figure 3, Supplementary Table 2)**.

SETTING UP A STEMI NETWORK

Despite national or regional challenges, the implementation of a STEMI network is always similar.

STAGE 1. PREPARATION PHASE

The first step is to set up a local task force and an action plan for developing the network. This task force is also responsible for assigning roles, developing standard protocols for diagnosis and treatment in cooperation with the regional stakeholders and, later, coordinating the network.

STAGE 2. MAPPING PHASE

In this phase, the task force identifies all potential pPCI and non-pPCI centres, estimates the distances and the time needed for transportation, checks the availability of EMS and contacts the centres and the EMS to confirm their willingness to participate and their

ability to cope with the demands. All these resources should be mapped to understand the regional situation and to determine the best possible layout of regional network(s).

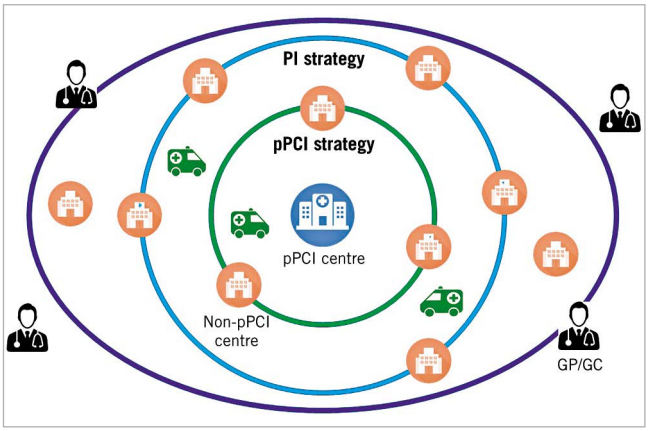
STAGE 3. BUILDING PHASE

Following the assumption that the role of each player in any network is always defined by the presence or absence of other players, any network can be categorised following the specifications in **Table 3** and the **Central illustration**. The task force assigns the individual roles to each player and nominates the coordinators of the centres, the EMS, and the GP/GC groups.

STAGE 4. QUALITY ASSESSMENT AND CONTINUOUS EDUCATION PHASE

Quality assessment

At least one basic set **(Supplementary Table 3, Supplementary Table 4)** of quality variables should be established[7]. This refers to the performance parameters of all network components and includes, e.g., presentation timing, rate of patients treated, procedural success and in-hospital mortality. The task force should meet periodically



Central illustration. *Typical combination of a hub-and-spoke network with an inner zone (green circle) organised as a pPCI network and an outer zone following a PI strategy (blue circle). The external purple zone represents a fibrinolysis network with no PCI centre in reach. GP/GC: general practitioner/general cardiologist; PI: pharmacoinvasive; pPCI: primary percutaneous coronary intervention*

Table 3. Network types according to existing resources.

Primary PCI networks	
Ranking	Optimal long-term solution for STEMI care.
Mandatory resources	pPCI centres which can be reached within 90 min after symptom onset or diagnosis of STEMI; EMS coordinated with the network.
Primary therapies offered	pPCI 24/7. If the pPCI centre is occupied or has a technical failure, a PI strategy is offered if pPCI cannot be offered within guideline-coherent timelines.
Processes	The EMS should bypass all other centres and transfer STEMI patients directly to the closest pPCI centre.
Hub-and-spoke PCI networks	
Ranking	Acceptable long-term solution for STEMI care.
Mandatory resources	pPCI centres; non-pPCI centres; EMS coordinated with the network.
Primary therapies offered	pPCI, PI strategy.
Processes	This model comprises two zones: the inner zone resembles a primary PCI network, the outer zone consists of non-pPCI centres or non-PCI hospitals which are connected to the inner zone via an EMS. They offer a PI strategy and either transfer the patient for PCI or perform PCI in the same place during office hours following the recommended timelines.
Important steps to upgrade	Turn non-pPCI centres into pPCI centres.
Pharmacoinvasive networks	
Ranking	Transient solution for STEMI care, should be upgraded in the midterm.
Mandatory resources	non-pPCI centres; an EMS, coordinated with the network, is highly desirable.
Primary therapies offered	PI strategy; primary PCI if patient arrives at PCI centre during office hours.
Processes	These networks offer a PI strategy 24/7 with fibrinolysis in all connected hospitals and either transfer the patient for PCI or perform PCI during office hours. pPCI is offered if patients arrive in a PCI hospital during office hours.
Important steps to upgrade	1. Introduce an EMS, coordinated with the network. 2. Turn non-pPCI centres into 24/7 pPCI centres.
Fibrinolysis networks	
Ranking	Transient organisation which provides basic care for STEMI patients. Should be upgraded as early as possible.
Mandatory resources	Medical centres without PCI option, able to recognise a STEMI and handle fibrinolysis; an EMS, coordinated with the network is highly desirable; a remote ECG interpretation service can be useful.
Primary therapies offered	Stand-alone fibrinolysis.
Processes	These networks offer application of fibrinolysis 24/7.
Important steps to upgrade	1. Introduce an EMS, coordinated with the network. 2. Install cath labs and expand their service to 24/7 pPCI.

cath lab: cardiac catheterisation laboratory; ECG: electrocardiogram; EMS: emergency medical service; FMC: first medical contact; PCI: percutaneous coronary intervention; PI: pharmacoinvasive; pPCI: primary percutaneous coronary intervention; STEMI: ST-elevation myocardial infarction

to analyse the performance and discuss necessary adaptations. The connection of reimbursement and compliance with standards can be a relevant steering instrument[11]. One question that remains unanswered is whether having too many pPCI centres in a region may be disadvantageous, since each single centre could end up having not enough experience and routine practice.

Continuous education for professionals

Not all professionals involved have a basic training in cardiology. It may be important to offer specific educational and training programmes for paramedics, nurses, technicians and non-cardiology physicians on a recurrent basis due to staff rotation.

Population awareness campaigns

Patient awareness of indicative symptoms and knowledge of how to seek medical attention effectively is key for the success of a STEMI network programme, since the longest delays are usually caused by the patients[12]. Awareness programmes involving social media, the entertainment industry, community organisations and scientific associations may be helpful; however, their effects quickly fade once they are discontinued[13].

Conclusions

The implementation of regional STEMI care systems overcomes local barriers and guarantees the best available reperfusion treatment for STEMI patients. A coordinated network of all stakeholders, guided by evidence-based, standardised protocols with a clear definition of roles and responsibilities is key and should be accompanied by a process of continuous improvement through evaluation of quality measures.

Conflict of interest statement

The authors have no conflicts of interest to declare.

References

The list of references can be found in **Supplementary Appendix 1**.

Supplementary data

Supplementary Appendix 1. References.

Supplementary Table 1. Reperfusion strategy of choice depending on the actual or estimated time period to reperfusion in STEMI networks.

Supplementary Table 2. Players in a STEMI network and their roles.

Supplementary Table 3. Minimal set of variables to be continuously monitored by all STEMI networks.

Supplementary Table 4. Target zones for quality metrics.

Supplementary Figure 1. Recommended actions in patients presenting via EMS according to system delay from STEMI diagnosis to pPCI.

Supplementary Figure 2. Recommended actions and reperfusion strategies for patients presenting at a non-PCI centre.

Supplementary Figure 3. Recommended actions and reperfusion strategy for patients presenting at a pPCI centre.

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Supplementary data

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Supplementary Table 1. Reperfusion strategy of choice depending on the actual or estimated time period to reperfusion in STEMI networks.

Reperfusion strategy	Recommendations
Primary PCI	- Emergency PCI without previous fibrinolysis is the preferred reperfusion strategy in STEMI patients within 12 hours of symptom onset. - Time from STEMI diagnosis to pPCI should be less than 120 minutes. If this target time cannot be met, fibrinolysis should be considered. - For non-PCI centres, the duration between patient arrival and transfer to a pPCI centre (DIDO) should be <30 minutes. - For patients presenting at a pPCI centre by their own means, time from STEMI diagnosis to reperfusion should be ≤60 min and ≤90 min in patients transferred from another centre or from outside the hospital.
Pharmacoinvasive approach or fibrinolysis	- If pPCI cannot be performed within 120 minutes from diagnosis, fibrinolytic therapy (preferably with fibrin-specific agents) is recommended within 12 hours of symptom onset in patients without contraindications. - Fibrinolysis should be started within 10 minutes of the STEMI diagnosis. Its efficacy should be evaluated by ECG after 60-90 minutes after fibrinolytics administration. - After fibrinolysis, transfer to a PCI centre is indicated to perform either immediate rescue PCI in case of unsuccessful fibrinolysis, or routine early PCI 2-24 hours after successful fibrinolysis in all other patients.
DIDO: door-in-door-out time; ECG: electrocardiogram; PCI: percutaneous coronary intervention; pPCI: primary percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction	

Supplementary Table 2. Players in a STEMI network and their roles.

Players	Basic set-up and key performance factors.
Patients	- Patients should be empowered to recognise suggestive symptoms of myocardial infarction and understand the importance of receiving urgent treatment. - They should understand how and when to activate the EMS if available or otherwise seek medical attention immediately. - Patient delay can be reduced by education and awareness campaigns. - Campaigns may have to be designed with respect to the regional specificities. Of note these campaigns for symptom recognition and appropriate notification of EMS had across the literature a rather transient or no effect. Alternative strategies including obligatory lessons in schools may be a better way to go. - If implemented, efficacy and effectiveness of campaigns should be measured.
General practitioners/ general cardiologists	- Record and interpret an ECG within the first 10 minutes of arrival. - After confirmation of the STEMI diagnosis, immediately summon EMS to transfer the patient according to the local EMS protocol to the next point in the local network which should ideally be the place of the destination therapy. - If an ECG cannot be recorded, the local EMS should be contacted immediately in case of symptoms suggestive of myocardial infarction. - In very remote regions, with no chance to transfer the patient to destination treatment in an acceptable time, enabling these units to administer fibrinolytics should be considered. Support could be granted by connecting them remotely with a cardiology unit for therapeutic guidance.
Emergency medical services	- All EMS call centre operators should be trained to recognise potential acute cardiac symptoms and dispatch appropriate EMS resources to the field. - Ideally, ambulances in the EMS should be equipped with an ECG recorder and defibrillator and at least one person in the car should be able to provide advanced life support. - All personnel (physicians, paramedics or emergency medical technicians) should be trained to recognise the symptoms of an acute myocardial infarction, administer oxygen as indicated, relieve pain and also provide basic life support. - Medical or paramedical personnel should ideally be able to interpret an ECG or alternatively have access to experienced staff who can establish the STEMI diagnosis and they should be able to administer pre-hospital fibrinolytics. - Protocols for regional networks should be able to ensure an effective EMS response and expeditious patient

	transfer in collaboration with emergency physicians, cardiologists and designated hospitals. - At the pre-hospital stage, any EMS should be able to perform three basic steps: i) rapid response to patient call, ii) electrocardiographic diagnosis within 10 min of arrival at the scene, and iii) a consequent triage and transfer guided by regional protocols based on estimated time from STEMI diagnosis to pPCI-mediated reperfusion. - In all cases the total scene time in the pre-hospital stage should be <15 min. - If pPCI is possible within 120 min from STEMI diagnosis, EMS should notify the centre prior to arrival and, if possible, transmit the ECG and the necessary documentation. - If the anticipated STEMI diagnosis to PCI-mediated reperfusion time is >120 min and if the EMS is equipped to do so, pre-hospital fibrinolysis may be considered, in absence of contraindications, on route to the PCI facility. - When fibrinolysis is contraindicated, patients should be transferred directly to a pPCI centre. - If pre-hospital fibrinolysis is not available, the patient should be transferred to the nearest non-PCI centre to administer fibrinolytics if possible, within the framework of a PI strategy. - It is also the task of an EMS to provide supportive treatment to assure relief of pain, breathlessness, and anxiety, and, where deemed necessary according to the guidelines, consider antiplatelet and anticoagulation therapy. - Between-hospital transfer should be coordinated to guarantee a rapid response and a timely transfer within the network.
Non-pPCI centres	- All non-pPCI centres should have constituted a STEMI team comprising personnel from patient registration, the emergency department and the coronary care unit or intensive care unit. - These centres must have developed standardised reperfusion and transfer protocols based on contraindication for fibrinolysis, proximity to PCI services and haemodynamic stability of the patient. - They should consider all STEMI patients as a high priority patient to transfer. - They must have a process in place for collection and monitoring of performance metrics. - They must have multidisciplinary team meetings to review and improve STEMI care, including ongoing staff training and assessment. - If they are located beyond 30 min transfer time to a PCI centre, they should administer fibrinolytics and transfer patients under the framework of a PI strategy. If patients are in cardiogenic shock or have contraindication for

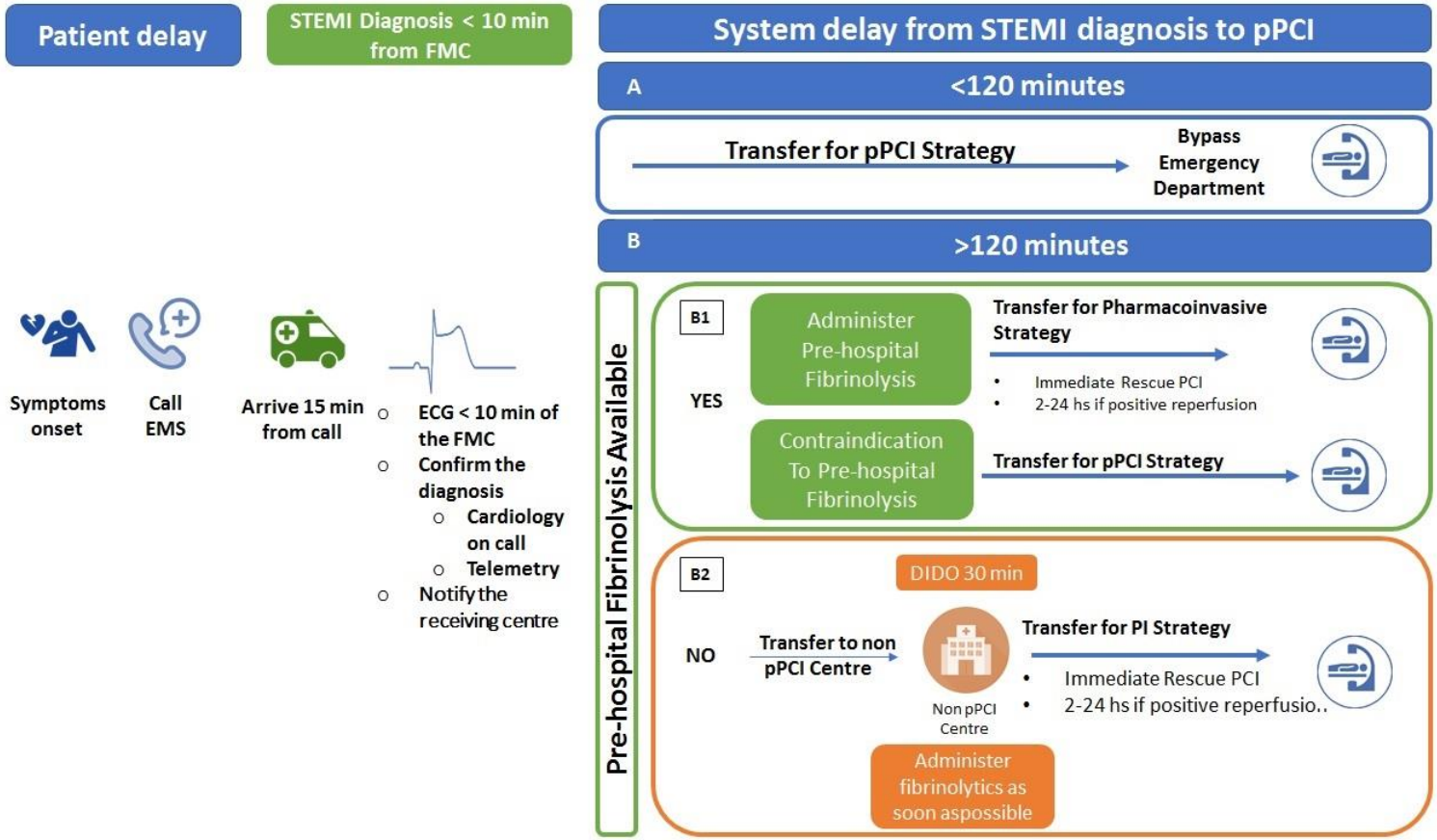
	fibrinolysis, they must be transferred for pPCI by any means. - If located within 30 min transfer time they should routinely transfer patients for a pPCI strategy if the pPCI centre is ready to accept the patient. If this is not the case a PI strategy needs to be considered. - The most important challenge for these units is to work in coordination with the EMS to be able to comply with a door-in-door-out time of 30 min.
pPCI centre	- Upon arrival at the pPCI centre, the patient should bypass the ED and be admitted directly to the cath lab. - The interventional cardiologist needs to be alerted as soon as a patient with possible STEMI is announced. - The interventional team needs to be onsite and ready ideally within 30 min after notification. - A pPCI centre must have trained operators with annual volumes of >75 procedures at institutions performing >400 PCIs per year. - Each centre should establish an institution-specific protocol to perform pPCI within 60 minutes from the STEMI diagnosis. - The centres must have constituted a STEMI team comprising personnel from patient registration, the emergency department, clinical cardiology and cath lab and EMS. - They must ensure a rapid admission process and prompt referral to the triage area of all patients with suspected acute coronary syndromes who arrive at the ED. - STEMI diagnosis needs to be rapidly established through recording of an ECG within 10 min of patient admission. - In each centre there must be a single call cath lab activation by ambulance personnel or ED physician. - Once established all the centres should have processes in place to collect and monitor performance metrics which are reviewed in a multidisciplinary team meeting to review and improve STEMI care. - All of them need to organise an ongoing staff training and assessment programme. - Optimally, any pPCI centre has a dedicated CCU/ICU which takes care of these patients.
cath lab: cardiac catheterisation laboratory; CCU: coronary care unit; ECG: electrocardiogram; ED: emergency department; EMS: emergency medical service(s); min: minutes; ICU: intensive care unit; PCI: percutaneous coronary intervention; PI: pharmacoinvasive; pPCI: primary percutaneous coronary intervention; STEMI: ST-elevation myocardial infarction	

Supplementary Table 3. Minimal set of variables to be continuously monitored by all STEMI networks.

Common	1. Time of symptom onset 2. Type of FMC 3. Time of FMC 4. Time of ECG
EMS	1. Time of activation 2. Time of EMS arrival at the scene 3. Time of EMS departure from the scene
pPCI centre	1. Time of patient arrival 2. Time of cath lab activation 3. Time of start of the procedure 4. Time of wire crossing
Non-PCI centre	1. Time of patient arrival 2. Time of fibrinolysis application 3. Time of EMS activation 4. Time of patient departure to PCI centre
cath lab: cardiac catheterisation laboratory; ECG: electrocardiogram; EMS: emergency medical service(s); FMC: first medical contact; PCI: percutaneous coronary intervention; pPCI: primary percutaneous coronary intervention	

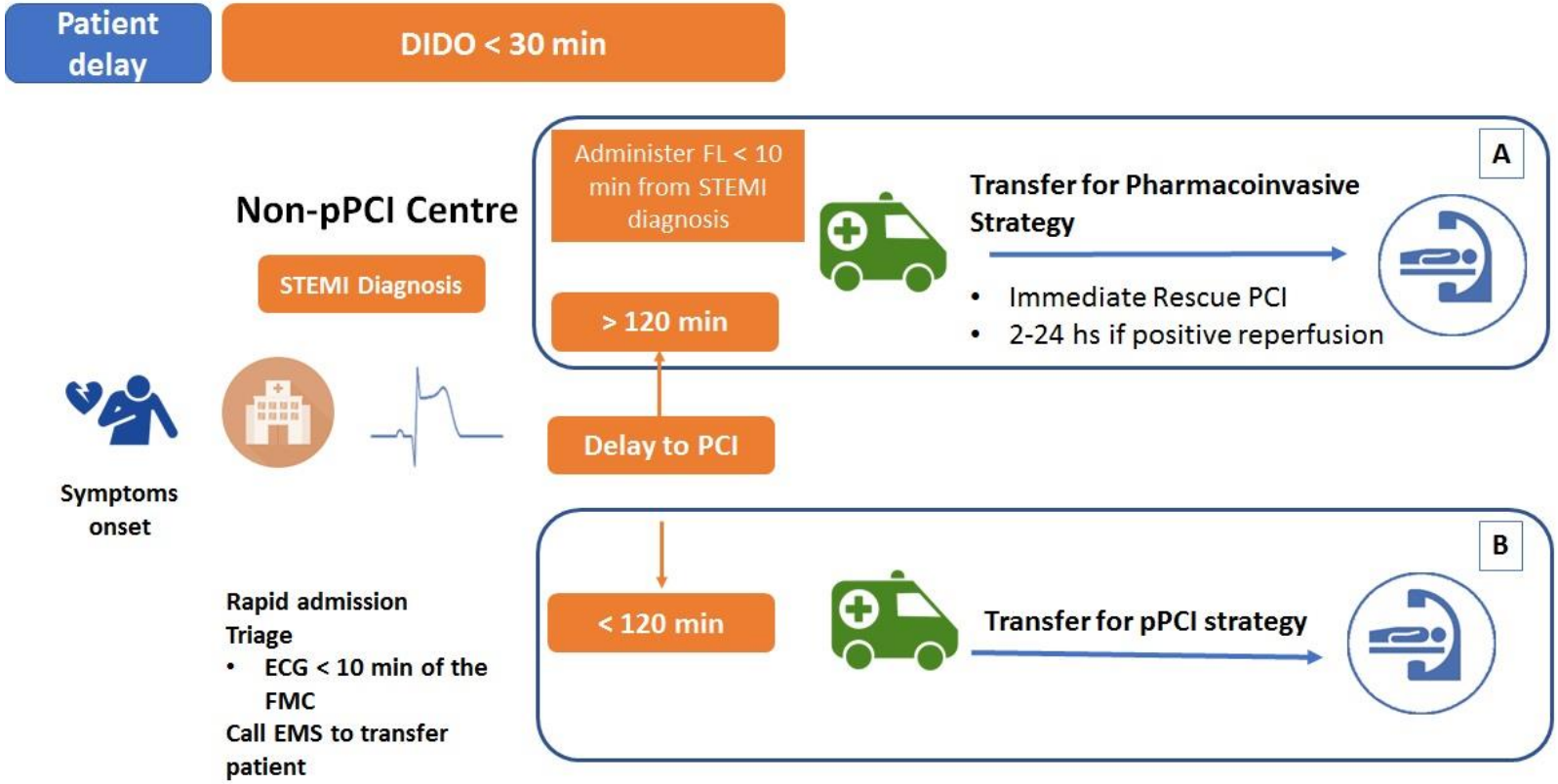
Supplementary Table 4. Target zones for quality metrics.

Reperfusion therapy	1. % of STEMI patients arriving in the first 12 hrs receiving reperfusion therapy 2. % of STEMI patients with timely reperfusion therapy according to FMC: a. EMS i. <90 min from STEMI diagnosis to wire crossing for pPCI strategy ii. <10 min from STEMI diagnosis to lytic administration for reperfusion with fibrinolysis b. PCI centre i. <60 min from STEMI diagnosis to IRA wire crossing c. For transferred patients: i. <120 min from STEMI diagnosis to IRA wire crossing for reperfusion with PCI ii. <30 min door-in-door-out for patients presenting at a non-PCI centre (en route to a PCI centre)
EMS: emergency medical service(s): IRA: infarct-related artery: PCI: percutaneous coronary intervention; STEMI: ST-elevation myocardial infarction	



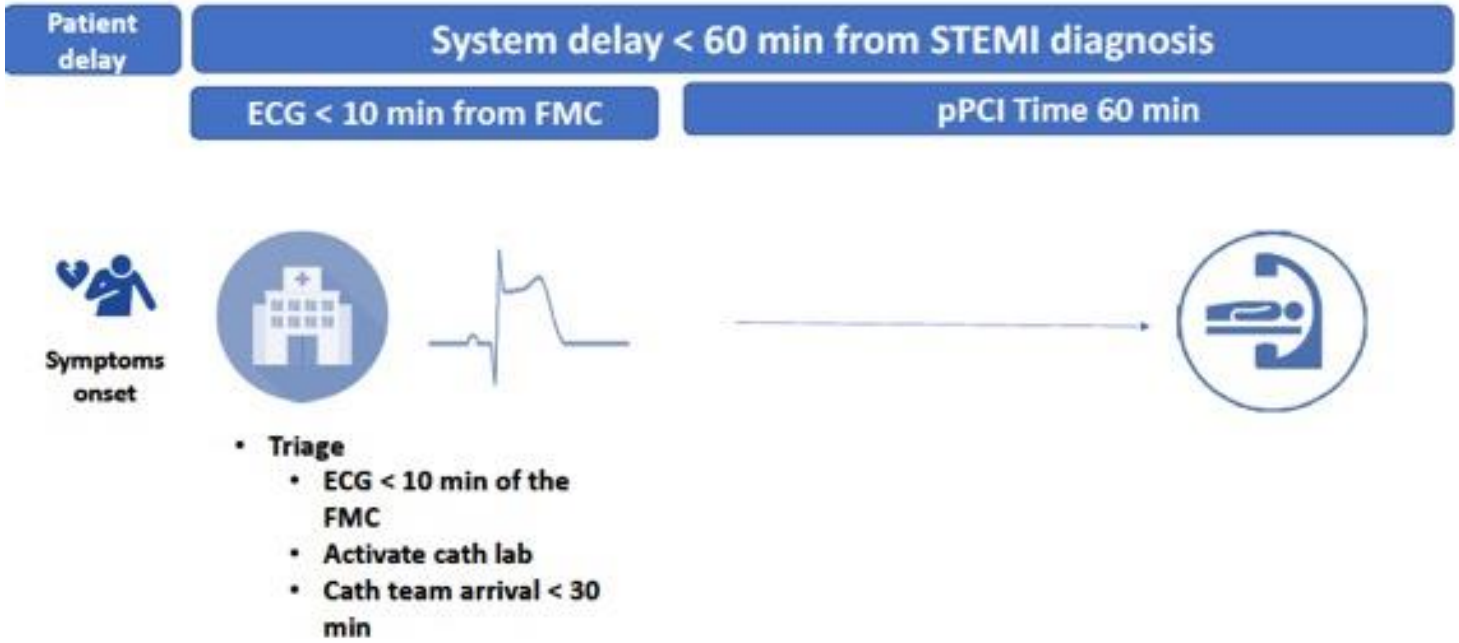
Supplementary Figure 1. Recommended actions in patients presenting via EMS according to system delay from STEMI diagnosis to pPCI.

DIDO: door-in to door-out time; ECG: electrocardiogram; FMC: first medical contact; PCI: percutaneous coronary intervention; pPCI: primary percutaneous coronary intervention; STEMI: ST-elevation myocardial infarction



Supplementary Figure 2. Recommended actions and reperfusion strategies for patients presenting at a non-PCI centre.

DIDO: door-in to door-out time; ECG: electrocardiogram; EMS: emergency medical services; FL: fibrinolysis; PCI: percutaneous coronary intervention; pPCI: primary percutaneous coronary intervention; STEMI: ST-segment elevation myocardial infarction



Supplementary Figure 3. Recommended actions and reperfusion strategy for patients presenting at a pPCI centre.

ECG: electrocardiogram; FMC: first medical contact; STEMI: ST-elevation myocardial infarction