Development of systems of care for ST-Elevation myocardial infarction patients. The emergency medical services and emergency department perspective.

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Abstract:

Central to the development of systems and centers of care for ST-elevation myocardial infarction (STEMI) patients will be the key role played by emergency medical services (EMS) at entry into the system and within the system when emergency interhospital transport is required.

Keywords: AHA Conference Proceedings | myocardial infarction | point-of-care systems | angioplasty | reperfusion

Article:

Current System of Care

Emergency Medical Services System Design

Prehospital EMS systems have 3 major components: emergency medical dispatch, public safety (fire and law enforcement) first response, and EMS ambulance response. Each of these operates within a broader emergency care system, which includes acute care facilities and regionalized healthcare services. In most states, an EMS regulatory entity within the state government oversees the emergency care system. Many states have regional EMS councils and advisory boards that function with varying levels of authority.

Emergency Medical Dispatch

Early access to EMS is promoted by a 9-1-1 system currently available to >95% of the US population. Enhanced 9-1-1 systems provide the caller's location and number to the dispatcher, which permits rapid dispatch of prehospital personnel to locations even if the caller is not capable of verbalizing or the dispatcher cannot understand the location and telephone number of the emergency. Although cellular phones have been problematic because they do not stay in a fixed location, new technology exists that allows triangulation of a cellular phone caller's location. This technology is being phased in throughout the country at a rapid pace.

In most communities, law enforcement or public safety officials are responsible for operating 9-1-1 centers, because in most locations, 85% of calls are for police assistance, 10% are for EMS, and 5% are for fire-related emergencies. Dispatchers who staff 9-1-1 centers may have minimal medical training, be emergency medical technicians, or on occasion be paramedics trained and certified as emergency medical dispatchers. In any case, dispatchers operate under standardized, written (often computerized) protocols. Such protocols are developed nationally and then modified locally or nationally. The ideal system has intense quality improvement programs to ensure that dispatchers follow protocols and procedures correctly and consistently. This is particularly true for the prearrival instructions that are given to cardiac arrest bystanders to instruct them on how to perform cardiopulmonary resuscitation (CPR) while awaiting arrival of emergency personnel (telephone CPR). Emergency medical dispatchers can also prompt patients with symptoms suggestive of an acute STEMI to take aspirin while awaiting the arrival of EMS personnel.

Public Safety First Responders

To minimize time to lifesaving treatment, most communities have volunteer and/or paid firefighters and/or law enforcement officers capable of administering first aid, oxygen, CPR, and, increasingly, early defibrillation with automated external defibrillators (AEDs) until the ambulance team arrives. The goal is to have a sufficient number of personnel to have a trained, equipped first responder at the victim's side in ≤5 minutes of the call. Most EMS systems will dispatch a first-responder unit along with an ambulance on suspected STEMI calls, such as those that involve chest discomfort or equivalent complaints, as well as other potentially life-threatening calls (eg, cardiac arrest or difficulty breathing).

Ambulance Responders

EMS ambulances are staffed by a variety of different personnel throughout the United States. Most urban and suburban ambulances are staffed with paid or volunteer fire department, third-service EMS, private or hospital-based, and/or volunteer rescue squad personnel. Most EMS systems are "tiered," which means that some of the ambulances are staffed and equipped at the basic life support emergency medical technician level (which includes first aid, CPR, and early defibrillation with AEDs), and other units (either transporting or nontransporting) are staffed by paramedics or other intermediate-level emergency medical technicians who can, in addition to basic care, start intravenous drips, intubate, and administer medications. In some systems,

advanced life support (ALS) providers can also perform 12-lead ECGs, provide external pacing for symptomatic bradycardia, and administer other advanced treatments. A minority of EMS systems provide only ALS ambulance service (an “all-ALS” model).

Rural areas provide primarily basic life support ambulance services, usually by volunteers supplemented by a relatively small number of ALS units. In some cases, ground ambulance paramedics or helicopter personnel respond to the scene (“ALS intercept”) in addition to a basic life support ambulance team to provide the higher level of service. When a ground ambulance is requested for interfacility transfer, a dispatch center may treat the request as a routine transport, which would result in a potentially avoidable delay.

Aeromedical services (helicopters and fixed-wing aircraft) are currently available throughout most of the United States for scene response to trauma and for interhospital transfer. Many communities use helicopter air ambulances to transport STEMI patients from noninterventional community hospitals to regional primary percutaneous coronary intervention (PCI) centers. In some cases, it may be quicker to transport such patients to a PCI center by a ground ALS ambulance (when available).

EMS Assessment, Triage, and Treatment of Suspected STEMI Patients

The American Heart Association (AHA) advanced cardiovascular life support chest pain algorithm importantly contributes to the prehospital assessment, triage, and treatment of patients with suspected STEMI in most EMS systems.[1] This algorithm recommends empirical treatment of suspected STEMI patients with morphine, oxygen, nitroglycerin, and aspirin (“MONA”). The American College of Cardiology (ACC)/AHA STEMI guidelines also recommend that 9-1-1 center emergency dispatchers ask patients with symptoms suggestive of an acute STEMI to take an aspirin (unless allergic) while first-responder and ambulance units are on the way.[2]

Because the majority of STEMI deaths occur in the first 2 hours due to cardiac arrest after the onset of symptoms, it is important for communities to strengthen their “chain of survival” by continued training of laypersons in CPR and the use of AEDs, including the deployment of AEDs in high-risk public locations (“public access defibrillation”).[3,4]

Prehospital 12-Lead Electrocardiography

It has been reported that approximately 4% to 5% of EMS patients with chest pain are having an acute STEMI.[5] Prehospital 12-lead ECG acquisition is critical for determining which chest pain patients need to be transported to a PCI-capable facility.[6–10] The ACC/AHA STEMI guidelines,[2] the 31st Bethesda Conference of the ACC,[11] and a recent technology review supported by the National Heart, Lung, and Blood Institute’s National Heart Attack Alert Program[12] strongly encourage the use of 12-lead ECGs by paramedics to evaluate all adult patients with nontraumatic chest discomfort. In a recent survey of EMS systems serving the 200 largest US cities, 84% of EMS systems reported that 12-lead ECGs were “available” in their system[13]; however, in the National Registry of Myocardial Infarction, a prehospital 12-lead ECG was recorded in <10% of STEMI patients.[10–14] It is not clear why there is such a disparity between reported availability and documented use.

In prehospital 12-lead ECG-equipped communities that permit transport of patients to both non-PCI-capable and PCI-capable hospitals, paramedics may fill out a fibrinolytic "checklist" and relay the ECG and checklist findings to the receiving hospital.[5,15] The checklist helps to determine the presence of comorbid conditions for which fibrinolytic therapy may be contraindicated. Local protocols usually dictate the destination hospital for such patients. Traditionally, most community protocols have directed EMS teams to bring chest pain patients to the nearest hospital, under the presumption that most hospitals could provide fibrinolysis if the patient was found to have an STEMI. The increasing use of a primary PCI reperfusion strategy is prompting many communities to consider whether it is better to bypass the closest facility in favor of bringing such patients to the nearest primary PCI-capable and available hospital rather than the nearest hospital.

In Boston, Mass, paramedics reliably recognize "definite STEMI" patients on the prehospital 12-lead ECG with high reliability.[16] Such patients are brought directly to the cardiac catheterization laboratory at a primary PCI-capable hospital. Patients with "possible STEMI" are evaluated in the emergency department (ED) before the catheterization laboratory is contacted.

Prehospital Fibrinolysis

Because randomized controlled trials of fibrinolytic therapy have demonstrated the benefit of initiating fibrinolytic therapy as early as possible after the onset of STEMI symptoms,[17,18] it would seem logical to expect that a greater number of lives could be saved if fibrinolytic therapy could be started by EMS providers.[19] A meta-analysis of prehospital-initiated fibrinolytic trials suggests that there is a 17% relative improvement in outcome associated with prehospital (versus ED) fibrinolysis.[20]

Most of these trials were conducted in Europe, where physicians staff ambulances, which makes the decision to administer fibrinolysis easier. Fibrinolysis works best in the first few hours after symptom onset when a fresh thrombus is susceptible to pharmacological dissolution.[21] The Myocardial Infarction Triage and Intervention (MITI) study in Seattle, Wash, failed to demonstrate a statistically significant overall mortality benefit for prehospital versus ED fibrinolysis. It did, however, show better outcomes with prehospital fibrinolysis in the subset of patients who were seen within 70 minutes of symptom onset.[17] In the CAPTIM (Comparison of Angioplasty and Prehospital Thrombolysis In acute Myocardial infarction) study conducted in France, where ambulances are staffed by physicians, prehospital fibrinolysis was equal to or superior to primary PCI when patients were treated within 2 hours of symptom onset. Patients treated after 2 hours of symptom onset had better outcomes with PCI.[22]

Although there are isolated areas in the United States that have instituted prehospital fibrinolytic programs,[23,24] the strategy has not been adopted widely, likely because of the high cost, difficulty in maintaining paramedic skills for an infrequently used treatment, relatively short transport times in many EMS systems, and potential for litigation if a fibrinolytic drug is administered to a patient who does not need it and there is a serious complication.[25,26] For these reasons, the ACC/AHA STEMI guidelines do not advocate a national policy of prehospital fibrinolytic therapy. The guidelines do support prehospital fibrinolysis in special settings in which physicians

are present in the ambulance or prehospital transport times are ≥60 minutes in high-volume EMS systems.[2]

ED Issues

Because both challenges in training and equipping EMS systems with 12-lead ECG and patient factors leading to non-EMS presentations will continue to exist in the foreseeable future, there is no realistic plan that can completely exclude the ED from being an integral part of STEMI care systems. Only 24% to 44% of all STEMI patients utilize EMS as the entry point in the medical system.[27] Instead, the majority of STEMI patients have their first medical contact on entry into the ED. This poses a special challenge to ED personnel, because STEMI patients arriving by ambulance typically receive attention and treatment faster than patients who transport themselves.[10,28,29] This issue is a particular problem in busy, overcrowded EDs.[30]

The current process for triaging, evaluating, and treating a suspected STEMI patient who presents to the ED includes a large number of potentially avoidable delays.[31] After ED arrival, the ambulatory patient typically undergoes a triage process, followed by emergency nurse and physician assessments. Patients presenting via EMS are usually placed immediately in treatment areas and assessed rapidly by emergency physicians and nurses. Emergency physicians and nurses stabilize the patients medically and begin administering adjunctive treatments (eg, aspirin, β-blockers, or anticoagulation). A 12-lead ECG is usually performed per protocol early in the ED course. The ACC/AHA guidelines recommend that the initial ECG be performed within 10 minutes of arrival, but depending on ED capacity, patients presenting with atypical symptoms for STEMI may wait in the waiting room because of their initial triage assessment. ED overcrowding has been demonstrated to result in delays in initiation of reperfusion therapy.[32] Depending on local practice patterns, multiple consultations with cardiologists and/or primary care physicians may be required to determine reperfusion strategy and the need for possible transfer to a primary PCI-capable hospital. These disorganized processes routinely cause delays to reperfusion.[33]

Many hospitals need to organize their response for patients presenting with symptoms suggestive of STEMI to ensure that the diagnosis can be confirmed and reperfusion therapy can be offered in the shortest possible time. The ACC/AHA STEMI guidelines recommend the establishment of multidisciplinary teams (including primary care physicians, emergency physicians, cardiologists, nurses, and laboratory personnel) who can develop guideline-based, institution-specific written protocols for triaging and managing patients who present with signs and symptoms suggestive of STEMI.[2]

For hospitals that use a primary PCI strategy, these protocols may include criteria and procedures for patients transported by ambulance with prehospital 12-lead ECG-confirmed STEMI to receive expedited emergency care and, when appropriate, to bypass the ED and go directly to the cardiac catheterization laboratory. An increasing number of hospitals are setting up “STEMI alert” teams patterned after “trauma alert” teams used at trauma centers. Such teams, typically consisting of representatives from the ED, the cardiology department, the coronary care unit, and the catheterization laboratory, can be alerted by a group telepage either when a STEMI patient is

being transported to the hospital by an EMS ambulance team that has performed a prehospital 12-lead ECG or on diagnosis of STEMI by an emergency physician.

The process in the non-PCI-capable hospital is nearly identical to that in the primary PCI-capable hospital with the exception that the activation of the STEMI alert system from outside the STEMI-receiving hospital results in the rapid assessment of available transportation options (by conference call or some other means), followed by a decision to either transport the patient or initiate fibrinolysis. This determination must be made soon after the patient arrives in the ED.

The Ideal EMS/ED System of STEMI Care

The ACC/AHA STEMI guidelines suggest that each community should develop a system of STEMI patient care that incorporates non-PCI-capable and primary PCI-capable hospitals. The trauma center model has been used successfully for decades to help communities optimize the care of seriously injured individuals. This model establishes a hierarchy of hospitals based on their 24-hour care capability. The lead trauma hospital in a region has responsibility for helping to coordinate the network and for conducting research and education. There is increasing support for implementation of the trauma center model for STEMI patient care that is integrated with the regional and statewide systems of care.[2]

The ACC/AHA STEMI guidelines also suggest that there should be a written plan and standards for STEMI patient assessment, treatment, and triage by EMS providers.[2] The plan should be developed with formal input from EMS agencies, cardiologists, emergency physicians and nurses, hospitals, and others. The plan should interface with that of neighboring communities and should include a requirement to track EMS and hospital performance with preestablished goals. EMS data should include sensitivity and specificity in 12-lead STEMI recognition and compliance with standards and protocols (including transport of non-STEMI cardiac patients to non-PCI-capable hospitals). A quality improvement program must be established that identifies a neutral oversight authority (with representatives from non-PCI-capable and primary PCI-capable hospitals) to collect and analyze data and provide feedback to EMS and hospital providers. An excellent model is the Boston (Mass) EMS system, which currently distributes STEMI patients to dedicated primary PCI centers using a predetermined plan and a highly effective quality improvement program.[34]

EMS systems need to have enough trained personnel and equipment to ensure that a 12-lead ECG can be performed on adults with nontraumatic chest pain or other symptoms suggestive of STEMI. There should be a written “point-of-entry protocol” that can guide EMS providers in determining where to transport suspected STEMI patients. The plan should designate regional primary PCI-capable hospitals where STEMI patients can be treated promptly by experienced operators 24 hours a day, 7 days a week.

In areas that have developed a well-functioning, regional primary PCI network, STEMI patients should be transported directly to the closest regional primary PCI-capable hospital if it can be reached (by ground or air) quickly enough that the time from initial patient contact to PCI is within 90 minutes. If this is not possible, fibrinolysis (prehospital or at the closest hospital ED)

should be given unless contraindicated, and arrangements should be made for transport to the nearest primary PCI-capable hospital.

A few large medical centers in the United States have established STEMI alert networks that provide integrated access to PCI services for both non-PCI-capable and PCI-capable hospitals. These systems aim to predetermine as many elements of strategic decision making as possible before the patient enters the system at all. The STEMI alert model is based on the use of group paging systems to activate parallel processes to shorten the time from initial medical contact to reperfusion therapy. This ideal model provides emergency physicians (and possibly trained prehospital personnel) with the ability to determine resource availability rapidly and mobilize cardiac catheterization laboratories. Time is saved by accelerating the decision-making processes and by having a team of providers performing multiple essential tasks simultaneously rather than sequentially. The STEMI alert model has been shown to reduce door-to-balloon times and promote a strategy of primary PCI.[35]Consideration should be given for EMS providers to sound a STEMI alert if they have a patient whose 12-lead ECG indicates the presence of STEMI.

Non-PCI-capable hospitals that receive a STEMI patient by ambulance or that identify STEMI in an ED walk-in patient should strongly consider immediate transfer of such a patient to a PCI-capable center if it can be accomplished promptly based on the above guidelines. Transferring facilities need to have an effective plan in place that ensures prompt response of the ground and/or air ambulance service to effect emergent interfacility transport of a STEMI patient who requires emergency revascularization. This transfer should be based on a 9-1-1 system and not a “next-available ambulance” protocol. If a transfer cannot be accomplished promptly, fibrinolysis should be considered on the basis of the patient’s risk and duration of symptoms, followed by consideration of transfer to a PCI-capable hospital.

Current Barriers and Gaps That Must Be Addressed by an Ideal System

Developing such an organized system of care for identifying, triaging, and treating STEMI patients is not without its challenges. At first glance, it appears that there might be strong economic disincentives for non-PCI-capable hospitals to participate in such a community program, because cardiovascular care is often a lifeline for a hospital’s financial success. It has been estimated that implementation of a prehospital triage strategy for patients with suspected STEMI would result in the diversion of 22% of patients with STEMI from hospitals without primary PCI capability, even if there was perfect specificity of prehospital triage.[36]STEMI patients only account for a small percentage (2% to 5%) of EMS chest pain patients, but the diminished prestige of non-PCI-capable hospitals may draw additional non-STEMI cardiac patients away from them. To survive, non-PCI-capable hospitals will need to continue to receive non-STEMI cardiac patients and will need financial support through changes in reimbursement schemes and sharing of finances across systems that include non-PCI-capable and primary PCI-capable hospitals. In addition, it is important to not overburden the EMS system and primary PCI-receiving facilities with non-STEMI patients.

Several other issues will need careful consideration. There is a lack of emergency physician training and leadership in systems of care for cardiovascular disease and a lack of collaboration between EMS, ED, and cardiology groups at individual hospitals. In many institutions, there is

also a lack of coordinated curriculum to teach ED staff to care for STEMI patients and a lack of feedback on performance or guideline compliance to EMS and ED personnel. Furthermore, with decreasing length of hospital stay and decreasing bed capacity, hospital overcrowding has resulted in ED overcrowding. The latter results in ED diversion and longer ED length of stay for patients with increasingly complex conditions. Finally, prehospital reimbursement (ie, for provider salary, equipment, training, medication, and interhospital transfer) is inadequate.

Recommendations

Research

EMS

1. Alternative options for modernizing and improving strategies for emergency medical response should be evaluated.
2. Whether transport of STEMI patients to a PCI-capable center (that is not the closest hospital) is safe should be determined.
3. The best approach to use of prehospital ECGs (ie, interpreted in the field or transmitted to the ED) should be determined.
4. The feasibility of emergency patient transfer in rural communities should be determined.
5. The effectiveness of the implementation of a comprehensive STEMI alert system should be evaluated.
6. Community-based research to help identify effective interventions for improving universal utilization of EMS for STEMI and eliminate associated regional variation should be promoted.
7. The efficacy of extending programs such as “Get With the Guidelines” and “Guidelines Applied to Practice” to include providers, hospitals, and EMS systems in improving adherence to STEMI guidelines should be evaluated.
8. Prehospital 12-lead ECG systems and reliability of data transfer should be evaluated.

Programs

EMS

1. Public CPR and AED education should be continued.
2. The AHA should partner with other stakeholder organizations to develop a module for EMS providers that addresses acute coronary syndrome/STEMI care, with particular emphasis on 12-lead ECG acquisition, transmission, and interpretation. Consideration should be given to including extension of ECG acquisition training to basic EMS providers.
3. Industry should continue to partner with EMS to enhance technology for ECG acquisition, transmission, and interpretation.

In All Hospitals

1. All STEMI hospitals should have written guidelines and standing orders for administration of fibrinolytic therapy and adjunctive treatments.
2. Mock STEMI drills should be encouraged in low-volume centers to maintain skill sets and to help further refine processes that cause delay at these individual institutions.

In PCI-Capable Hospitals

1. Designated emergency physician and nurse leaders and cardiologists should be identified and involved in their institution's STEMI system development, management, quality improvement, and outreach to referring hospitals, physicians, and EMS providers.
2. The hospital administration should provide infrastructure support to the emergency physician and nurse and cardiology leaders, which should include protected time for activities related to STEMI system management.
3. Protocols should be established that allow EMS-diagnosed STEMI patients to bypass the ED to go directly to the cardiac catheterization laboratory when appropriate.

In Non-PCI-Capable Hospitals

1. Predetermined clinical pathways should be used that allow for the rapid determination of appropriateness of transfer for primary PCI based on time of symptom onset and projected transport times.

Policy

EMS

1. There is a critical need for expeditious and systematized transport of patients from non-PCI-capable hospitals to PCI-capable centers. Such requests for transfer need to be handled by the transporting ambulance agency with the same urgency as a 9-1-1 emergency call.
2. Aggressive implementation of public access defibrillation in high-risk public locations should be promoted.
3. Scripted interrogation protocols/prearrival instructions for phone CPR and administration of aspirin while EMS personnel are en route to the scene should be developed.
4. Continued emergency medical dispatcher training and certification requirements should be developed and maintained.
5. EMS agencies need to have sufficient personnel, training, and resources to ensure that a prehospital 12-lead ECG can be acquired from prehospital patients with clinical presentations suggestive of STEMI to assist in triage, treatment, and point-of-entry decisions.
6. Reimbursement rates for interfacility STEMI patient transport must reflect the increased level of response capability.
7. Data collection and quality improvement systems need to be developed to oversee the continuum of STEMI patient care.

In All Hospitals

1. All ED-based STEMI protocols should emphasize rapid evaluation and decision making to determine reperfusion strategy and to administer adjunctive medical treatments as appropriate. Process maps are helpful in the development phase of these protocols.
2. Emergency physicians in all STEMI hospitals should be empowered to activate cardiac catheterization laboratory resources within a standardized clinical pathway without fear of reprisal for false-positive activation.
3. All ED staff taking care of STEMI patients should complete specific educational modules adapted to the local process.
4. All participants in a STEMI system should receive formal feedback as part of an organized quality improvement process.
5. ED personnel should be trained to interpret ST-segment elevation on an ECG.

In Non-PCI-Capable Hospitals

1. Whenever possible, patients should be transferred directly from the referring hospital ED to the cardiac catheterization laboratory.
2. When a patient is transported to a non-PCI-capable hospital, he or she should remain on the stretcher while being evaluated for possible transport to a PCI facility, and intravenous infusion (tubing) should be minimized.

Disclosures

Potential conflicts of interest for members of the writing groups for all sections of these conference proceedings are provided in a disclosure table included with the Executive Summary.

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Footnotes

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