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SPECIAL ARTICLE

Pre-Hospital 12-Lead Electrocardiography Programs

A Call for Implementation by Emergency Medical Services Systems Providing Advanced Life Support—National Heart Attack Alert Program (NHAAP) Coordinating Committee; National Heart, Lung, and Blood Institute (NHLBI); National Institutes of Health

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Emergency medical services (EMS) providers who administer advanced life support should include diagnostic 12-lead electrocardiography programs as one of their services. Evidence demonstrates that this technology can be readily used by EMS providers to identify patients with ST-segment elevation myocardial infarction (STEMI) before a patient's arrival at a hospital emergency department. Earlier identification of STEMI patients leads to faster artery-opening treatment with fibrinolytic agents, either in the pre-hospital setting or at the hospital. Alternatively, a reperfusion strategy using percutaneous coronary intervention can be facilitated by use of pre-hospital 12-lead electrocardiography (P12ECG). Analysis of the cost of providing this service to the community must include consideration of the demonstrated benefits of more rapid treatment of patients with STEMI and the resulting time savings advantage shown to accompany the use of P12ECG programs. (J Am Coll Cardiol 2006; 47:485–91) © 2006 by the American College of Cardiology Foundation

Coronary heart disease, the single largest cause of death in U.S. men and women, was responsible for more than one in every five deaths in 2002. According to the latest estimates, as many as 1.2 million Americans experience an acute myocardial infarction (AMI) each year, resulting in over 494,300 deaths (1).

A decade has passed since a working group of the National Heart Attack Alert Program (NHAAP) published "60 Minutes to Treatment," a position paper on rapid identification and treatment of patients with AMI (2). This statement challenged the U.S. health care system to provide definitive artery-opening (reperfusion) treatment (notably fibrinolytic) to eligible AMI patients within 60 min of symptom onset, and within 30 min of arrival at the hospital. These benchmarks are critical because the benefits of AMI treatment diminish rapidly over time (3). Early reperfusion treatment for eligible AMI patients has a significant impact on morbidity and mortality (4). The benefit of a shorter time to artery-opening treatment with fibrinolytics and percutaneous coronary intervention (PCI) has been conclusively shown for patients with ST-segment elevation myocardial infarction (STEMI) (4–7). For fibrinolytic therapy, the beneficial effects are substantially greater in patients treated early after symptom onset than in those treated later, and mortality reduction is greatest among patients presenting to the hospital within 1 h of symptom onset. The benefit of fibrinolytic therapy initiated within 30 to 60 min after the onset of symptoms is estimated to result in 60 to 80 additional patients alive, at one month, per 1,000 patients treated with conventional therapy (8). These data support the well-known concept of a "golden hour" for AMI. The importance of total ischemic time has also been described for artery-opening treatment by PCI (6,9–11). The length of time from symptom onset to balloon inflation has been shown to be significantly correlated with one-year mortality (6). While PCI confers a higher rate of reperfusion, notably in patients presenting later in the course of infarction, myocardial necrosis is related to the duration of occlusion of the infarct-related artery, particularly in patients at greater risk (6). Thus, the time to opening of the infarct-related artery is important for patients who receive PCI as well as fibrinolysis (12).

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Abbreviations and Acronyms

ACC	= American College of Cardiology
ACI-TIPI	= acute cardiac ischemia time-insensitive predictive instrument
ACS	= acute coronary syndromes
AHA	= American Heart Association
AHRQ	= Agency for Healthcare Research and Quality
ALS	= advanced life support
AMI	= acute myocardial infarction
ED	= emergency department
EMS	= emergency medical services
EMT-P	= emergency medical technician-paramedic
PCI	= percutaneous coronary intervention
P12ECG	= pre-hospital 12-lead electrocardiography
STEMI	= ST-segment elevation myocardial infarction

The use of measurable time intervals (e.g., from arrival at the emergency department [ED] ["door"] to the initial electrocardiogram ["data"], and from the decision to treat ["decision"] to fibrinolytic drug administration time ["drug"]) has been promoted as a means for individual hospitals to study their system of care, implement changes in their processes, and improve performance relative to these benchmarks (2). Many hospitals can now state that definitive care is provided to STEMI patients within the benchmark time interval starting with arrival at the ED, but the proportion of patients treated within 60 min of symptom onset is only 4% for fibrinolytics and less than 1% for PCI (E. Stoehr, National Registry of Myocardial Infarction, personal communication, July 2004). Given the previously published time-to-treatment goals and the increased availability of PCI as an option for these patients, the American College of Cardiology (ACC) and the American Heart Association (AHA) recommend that after eligible STEMI patients present to the "medical system" (either emergency medical services [EMS] or the ED), they should receive fibrinolytic therapy within 30 min or PCI within 90 min (13).

For these benchmarks to be met, emphasis on further improvements in the time to definitive care for patients with STEMI must look to pre-hospital factors. Patient and bystander delays are responsible for the greatest proportion of delay before treatment (14). Major clinical trials show that the median time from symptom onset to treatment of persons with STEMI is approximately 2 to 3 h (15–17). Patient-related delay in seeking treatment has remained largely unchanged over the last decade, even though studies have shown that the effectiveness of reperfusion therapy depends on timely intervention (16,18–20). The full potential of current artery-opening treatments has not been realized because many patients are not seen in the hospital in time to fully reap their benefits (18,21).

Patients' recognition of symptoms, their motivation to seek care very early in the course of symptoms, and their use of EMS to provide immediate care will ultimately increase the number of persons receiving care within 60 min of symptom onset (22). Two educational initiatives, the National Heart, Lung, and Blood Institute's "Act in Time to Heart Attack Signs," campaign (23,24) and the Society of Chest Pain Centers' "Early Heart Attack Care" program (25,26), target educating potential patients (and others who may be in a position to help patients act quickly) to recognize and respond to symptoms associated with acute coronary syndromes (ACS). Community intervention and educational campaigns may promote the appropriate use of EMS by potential AMI patients (27).

The use of EMS in itself has been shown to be associated with earlier evaluation in the ED, wider use of acute reperfusion therapies, and less time between arrival at the ED, to fibrinolytic therapy or urgent PCI (17,28–32). Even though use of EMS is associated with earlier evaluation and treatment in the hospital setting, only 10% to 59% of patients with chest pain use such services for treatment and transportation to the hospital (17,29,30,33,34). Most patients are driven by someone else (about 60%) or drive themselves to the hospital (nearly 16%) (29,33). Emergency medical services is the only means by which patients can obtain the earlier evaluation and treatment benefit associated with pre-hospital 12-lead electrocardiography (P12ECG).

Pre-hospital electrocardiographs are usually sold as additional modular components or integrated into monitor-defibrillator devices. Pre-hospital 12-lead electrocardiography entails application of recording electrodes, capture of electrocardiographic data, automated interpretation using diagnostic algorithms within the device, transmission capability, and the option for over-read of the output by paramedics. The quality of P12ECG data has been shown to be equal to that obtained in the hospital (35,36). Pre-hospital 12-lead electrocardiographic data are readily obtained at the point of care of the patient in the pre-hospital environment, without undue delay in transportation to the hospital (35,37–39). Although a longer time from symptom onset to hospital presentation for the P12ECG group was reported in one series (40), the time to in-hospital reperfusion was significantly less in the P12ECG group. Printable copies of P12ECG data can be sent to hospital EDs via cellular telephone, or direct medical oversight physicians can discuss the paramedic's interpretation and other relevant aspects of the patient's symptoms, risk profile, and response to initial therapy. While many EMS providers are trained in the interpretation of 12-lead electrocardiography, and computerized algorithms provide diagnostic statements that paramedics can over-read, it is also possible to receive real-time remote interpretation of pre-hospital 12-lead electrocardiograms by expert physician electrocardiographers (41). The pre-hospital 12-lead electrocardiogram should be expeditiously over-read by a qualified physician.

Benefits of a P12ECG. The pre-hospital 12-lead electrocardiogram has favorable diagnostic and clinical impact ratings. The Agency for Healthcare Research and Quality (AHRQ) included P12ECG in its assessment of a wide