

Cardiac time-insensitive predictive instruments (TIPIs): real-time emergency clinical decision aids and tools for the retrospective assessment of care

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In the United States, acute cardiac ischemia (ACI), including both unstable angina pectoris and acute myocardial infarction (AMI), is the leading cause of morbidity and mortality, and an enormous consumer of health care resources. Accordingly, the use of hospital and intensive care beds for patients suspected to have ACI is a major health care expense. Yet of the approximately three million patients hospitalized for suspected ACI each year, over half prove not to have true ACI, and less than half of those with ACI have AMI.¹⁻³ These unnecessary hospital and coronary care unit (CCU) admissions represent a substantial waste; the direct costs alone are several billion dollars annually.⁴

Although the high proportion of seemingly unnecessary hospitalizations is not desired, it has been assumed that a more restrictive hospital admission policy would increase the number of patients with AMI inappropriately sent home. Generally, about 2% of those who have AMIs and those who have unstable angina are mistakenly sent home.^{5,6} Thus, beyond reducing the costs of unnecessary false positive admissions, there is also growing interest in reducing the false negative AMI discharge rate with the growing number of acute interventions for treating arrhythmias and for preventing or reducing AMI size. Among the diagnostic methods used to try to improve the accuracy of emergency department (ED) triage of patients with suspected ACI are the use of identification of high-risk clinical indicators, special electrocardiograph (ECG) leads, rapid determination of cardiac enzymes and other biomarkers, two-dimensional echocardiography, radionuclide perfusion imaging, and others.⁷ However, none of these has been shown prospectively to improve the accuracy of hospital and CCU admissions for patients with suspected ACI.⁷

In recent years, there has been work to devise mathematically based decision aids to try to improve ED triage.⁷ What is the current status of these ED triage decision aids? The ultimate measure of a prediction rule is its effect on patient care.⁸ Before being recommended for general use, clinical trials of any decision aid should demonstrate that it actually will safely improve ED triage and hospital and CCU admissions, especially given the risks inherent in reducing admissions and the general lack of experience with such tools.^{7,9}

To date, the only aids shown to be effective in such trials are the original ACI predictive instrument¹⁰ and its newer version, the ECG-based ACI time-insensitive predictive instrument (ACI-TIPI).¹¹⁻¹³ Conventional ECGs that have ACI-TIPI software print, on the ECG, a 0% to 100% prediction of a patient's probability of having ACI (Figure 1). A related AMI mortality TIPI, predicting cardiac mortality among presenting ED patients, has been published,¹⁴ but has been primarily used for retrospective comparisons between hospitals of clinically accurately risk-adjusted mortality rates rather than for real-time clinical use. However, a newer version of the mortality TIPI that includes in its predictions the impact of the use of thrombolytic therapy, the thrombolytic predictive instrument (TPI),¹⁵ is now available in conventional ECGs. When implemented in an ECG, the TPI software detects the ST-segment elevation of AMI, and then immediately prints on the ECG header its predictions of the likely beneficial and adverse effects on clinical outcomes from the use of thrombolytic therapy for AMI for a given patient (Figure 2). These predictions assist ED clinicians' real-time clinical decision making. Given the great importance of rapid, appropriate triage and treatment for patients with suspected ACI/AMI, these decision aids seem to hold considerable promise. The results of the 10,689-patient ACI-TIPI clinical trial showed that the ACI-TIPI does improve ED triage,^{12,13} and the results of the 28-hospital TPI clinical trial are due out soon. The results of clinical impact trials of these and other decision aids will provide a better picture of the proper role of such tools in the clinical setting.

In conjunction with testing of these cardiac predictive instruments for real-time clinical decision support, the ACI-TIPI, TPI, and other TIPIs can be used to provide retrospective feedback, as they are "time-insensitive" and therefore are not sensitive to whether used in real-time or applied after the fact for review of care.^{11,14,16} Examples of feedback reports based on the ACI-TIPI are shown in Figure 3, which compares hospitals by their respective triage of ED patients. The report shows that, in general, patients with higher ACI-TIPI probabilities of ACI tend to be sent to the CCU, and those with lower probabilities tend to go to the telemetry ward or home, but there are clear differences in triage practices between the hospitals. Figure 4 uses the same type of data to look at physician performance within one of the hospitals from the prior report (Hospital F). Again, the differences in average ACI-TIPI probabilities among patients sent to different dispositions vary considerably. A different type of ACI-TIPI "basal" report is shown in Figure 5. This report lists patients sent home from the ED with probabilities of ACI of greater than 10% among the same group of hospitals, and Figure 6 shows the same type of report done within a single hospital (Hospital F). Hopefully such reports will, by providing useful clinically based feedback, contribute to the improvement of direct clinical care, the overall management of care, and communication among

those involved in the different facets of care.¹⁶ Only with further experience and extensive development and evaluation efforts will the full impact of TIPIs and other such tools be known. Nonetheless, those now available in conventional ECGs appear to have significant promise for assisting ED triage and treatment of patients with chest pain and other symptoms suggestive of ACI, and deserve serious consideration among the tools used to optimize ED triage.

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