Differenentiating ST-Elevation Myocardial Infarction from Nonischemic ST-Elevation in Patients With Chest Pain

Viet Tran, MDa, Henry D. Huang, MDa, Jose G. Diez, MDa,b, Gerardo Kalife, MDb, Rajiv Goswami, MDa, David Paniagua, MDa, Hani Jneid, MDa, James M. Wilson, MDa,b, Scott R. Sherron, MDb, and Yochai Birnbaum, MDa,b,*

Current guidelines state that patients with compatible symptoms and ST-segment elevation (STE) in ≥2 contiguous electrocardiographic leads should undergo immediate reperfusion therapy. Aggressive attempts at decreasing door-to-balloon times have led to more frequent activation of primary percutaneous coronary intervention (pPCI) protocols. However, it remains crucial to correctly differentiate STE myocardial infarction (STEMI) from nonischemic STE (NISTE). We assessed the ability of experienced interventional cardiologists in determining whether STE represents acute STEMI or NISTE. Seven readers studied electrocardiograms of consecutive patients showing STE. Patients with left bundle branch block or ventricular rhythms were excluded. Readers decided if, based on electrocardiographic results, they would have activated the pPCI protocol. If NISTE was chosen, readers selected from 12 possible explanations as to why STE was present. Of 84 patients, 40 (48%) had adjudicated STEMI. The percentage for which readers recommended pPCI varied (33% to 75%). Readers' sensitivity and specificity ranged from 55% to 83% (average 71%) and 32% to 86% (average 63%), respectively. Positive and negative predictive values ranged from 52% to 79% (average 66%) and 67% to 79% (average 71%), respectively. Broad inconsistencies existed among readers as to the chosen reasons for NISTE classification. In conclusion, we found wide variations in experienced interventional cardiologists in differentiating STEMI with a need for pPCI from NISTE. © 2011 Elsevier Inc. All rights reserved. (Am J Cardiol 2011;108:1096–1101)

Current guidelines for acute ST-segment elevation myocardial infarction (STEMI) emphasize the need for shortening door-to-balloon times in patients presenting with symptoms suggestive of myocardial ischemia and STE1–3 and encourage making triage decisions based on prehospital 12-lead electrocardiographic (ECG) transmission.4,5 However, although this approach has been shown to shorten times to the catheterization laboratory, less is known about the accuracy of such an approach. In the absence of ECG signs of left ventricular hypertrophy (LVH) or left bundle branch block, guidelines define STE as new STE at the J point in ≥2 contiguous leads with cut-off points of ≥0.2 mV in men and ≥0.15 mV in women in leads V2 and V3 or ≥0.1 mV in other leads.9 However, nonischemic STE (NISTE) is found in >90% of healthy men.7,8 Up to 15% of patients presenting with chest pain have NISTE.9–13 In the present study we assessed the ability of interventional cardiologists to differentiate between STEMI and NISTE using only electrocardiograms of consecutive patients for whom the primary percutaneous coronary intervention (pPCI) protocol had been activated by emergency department physicians.

*Corresponding author: Tel: 713-798-2735; fax: 713-798-0270. E-mail address: ybirnbaum@bcm.edu (Y. Birnbaum).

Methods

A database of a large urban medical center contained records of 240 consecutive patients for whom the pPCI protocol had been activated because of suspected acute STEMI from January 2008 through December 2008. Two readers (V.T. and H.D.H.) collected 84 electrocardiograms showing STE in ≥2 contiguous leads. Patients with left bundle branch block or ventricular rhythms including electronic ventricular pacing were excluded. We also excluded patients whose patterns of STE did not meet guideline-based criteria for acute STEMI.

To confirm that ECG STE represented true acute STEMI, we performed detailed chart reviews that included final diagnoses from the in-hospital physician’s progress and discharge notes and examined reports of in-hospital coronary angiograms and echocardiograms. We also independently confirmed that those cases diagnosed as acute STEMI demonstrated the typical increase and decrease in cardiac marker levels (e.g., cardiac troponin I and creatine kinase-MB) consistent with STEMI and that subsequent ECG tracings showed the typical evolution indicative of STEMI.

Seven experienced interventional cardiologists were then asked to analyze the electrocardiograms after all identifying information was removed and to decide whether they would send these patients for pPCI based on ECG findings alone, assuming patients had appropriate corresponding symptoms. Readers were blinded to clinical information for each patient including age, ethnicity, and gender; types of symp-
toms; and the clinical setting in which pPCI was activated. If readers did not think ECG findings warranted pPCI protocol activation, they were asked to code the electrocardiogram as NISTE and then choose from a list of 12 possible explanations as to why STE was present. Readers were allowed to code 1 reason to explain the cause of NISTE for each case. Readers were then assessed for overall accuracy, sensitivity, specificity, and positive and negative predictive values in correctly identifying patients with adjudicated STEMI.

Results

Forty patients (48%) had adjudicated true STEMI and 44 patients (52%) had NISTE (13 of these patients [30%] had positive cardiac markers supportive of non-STEMI). Of the 84 patients (59 men, average age 61 years, range 25 to 90), 32 patients (38%) were white, 32 (38%) African-American, 12 (14%) Hispanic, and 9 (10%) of other ethnicities. Of the presenting symptoms, 62 patients (74%) had chest pain, 10 (12%) had shortness of breath, 5 (6%) had weakness, and 7 (8%) had other symptoms. With regard to risk factors, 57 patients (68%) had a previous diagnosis of hypertension, 46 patients (55%) had dyslipidemia, 30 patients (36%) had diabetes mellitus, and 27 patients (32%) had previously established coronary artery disease.

Percent electrocardiograms for which pPCI was recommended varied widely among readers (33% to 75%), with sensitivities ranging from 53% to 83% (mean 71%), speci-
ficiencies from 32% to 86% (mean 63%), positive predictive values from 52% to 79% (mean 66%), and negative predictive values from 67% to 79% (mean 71%; Figure 1). Even when readers chose NISTE as the diagnosis, the cause varied (Table 1). LVH, which is commonly found in our patient population, was thought to be the cause of NISTE by the individual readers in 6% to 31% of patients. Readers chose the option of old MI/aneurysm in 10% to 26% of cases. Interestingly, STEMI with spontaneous reperfusion as an indication not to activate the catheterization laboratory for possible pPCI was the least frequent choice (0% to 5%) in all patients with suspected NISTE.

Discussion

We show that although 74% of patients presented with the classic symptom of chest pain, 32% had known coronary artery disease, only 48% had true STEMI. We found wide variance in the overall sensitivity and specificity of our readers in distinguishing between STEMI and NISTE. Our results confirm that even in patients with corresponding symptoms of STEMI and for whom the pPCI protocol was activated, it remains difficult for experienced interventional cardiologists to determine by ECG criteria alone if patients have true STEMI or if they have NISTE. In a previous study using electrocardiograms of consecutive patients showing STE that were not necessarily recorded in the acute setting, we found a similarly wide discrepancy in the range of sensitivity in experienced electrocardiographers.14

Figures 2 and 3 depict 4 representative cases. Figure 2 shows a patient with adjudicated anterior STEMI; however, only 3 readers chose STEMI, whereas the other 4 decided that the patient had NISTE, all marked the option “old MI/aneurysm without acute changes” and 1 added the option “lack of reciprocal changes.” Figure 2 also shows a patient with NISTE. Four readers thought that the patient had STEMI. Of the 3 readers who marked “NISTE,” 2 chose “early repolarization pattern” as the cause and the other chose “STE secondary to LVH.” Figure 3 shows a patient with adjudicated STEMI, but only 1 reader thought as such. Two readers chose early repolarization pattern, 3 chose “pericarditis” (with 1
reader adding “concave STE”), and 1 made a diagnosis of NISTE because there were no reciprocal changes. The second electrocardiogram in Figure 3 shows NISTE. One reader thought that the patient had STEMI. Three readers decided that the patient had NISTE because the STE was concave (Figures 2 and 3, Table 1). Indeed, this patient has LVH criteria but STE secondary to LVH is typically seen in leads V1 to V3 and not in the inferior leads. Moreover, this patient had narrow but deep q waves in the inferior leads that 2 readers thought were representative of an old MI or aneurysm. However, echocardiogram revealed LVH without any regional wall motion abnormalities.

Electrocardiograms recorded in the field by emergency medical service teams can be interpreted at the site or electronically transmitted for interpretation at specialized centers, local emergency departments, experienced electrocardiographers, or on-call interventional cardiologists. It should be noted that in the United States, when prehospital electrocardiograms are transmitted, patients’ names and other identifying details must be omitted to comply with Health Insurance Portability and Accountability Act (HIPPA) regulations. Therefore, even if previous electrocardiograms exist in hospital medical records, readers would have no access to these. This is not the case in other countries, where the reader may have access to an electronic archive of electrocardiograms. Systems have been developed in which the interpreting physician communicates with the patient and the emergency medical service team by mobile telephone in addition to reading the transmitted electrocardiogram. It has not yet been determined if this...
approach improves the accuracy of pPCI activation compared to blind ECG interpretation.

The reported percent false activation of pPCI protocols varies from 5% to 25%. Results from a recent pooled analysis of 10 prospective observational registries involving 72 hospitals showed that pPCI was performed in only 76% of the 2,712 patients given a diagnosis of STEMI by the transporting emergency medical service team. Previous studies showed that wireless ECG transmission decreases door-to-balloon times, however, these studies did not examine differences in clinical outcomes or cost benefits.

The alternative of using automated ECG interpretive algorithms to speed decision making has been investigated; however, they showed lower sensitivity. Clark et al suggested that the classification of appropriate versus inappropriate activation of the pPCI protocol is strongly dependent on the interventional cardiologist, and when the pPCI protocol is deactivated by an interventional cardiologist and no angiography is performed, the case can be classified as inappropriate activation. However, it would be incorrect to assume that the interventional cardiologist is always right because, as results of the present study show, the accuracy of off-line reading by experienced interventional cardiologists is far from perfect.

As the population ages and the prevalence of baseline ECG abnormalities increases, diagnosing STEMI in the presence of baseline STE caused by LVH, repolarization abnormalities, or long-term infarction or aneurysm will become only more challenging. As a result, if a wireless triage method were to be implemented, it could further increase false activations of the pPCI protocol when patients present with symptoms compatible with STEMI unless easy access to a patient’s previous electrocardiograms is enabled.

Results of our study confirm that a diagnosis of STEMI from the electrocardiogram alone can be challenging in a population with a high prevalence of abnormal baseline electrocardiograms. Thus, from a cost–benefit and clinical outcomes standpoint, there could be significant problems if wireless ECG transmission programs without access to previous electrocardiograms and/or communication with a patient were the only approach implemented. To our knowledge, there has been no study that proves this strategy alone would lead to improved clinical outcomes in patients who present with chest pain.

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