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Clinical Investigations

Initial Presenting Electrocardiogram as Determinant for Hospital Admission in Patients Presenting to the Emergency Department with Chest Pain: A Pilot Investigation

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Summary

Background: Evaluation of chest pain accounts for millions of costly Emergency Department (ED) visits and hospital admissions annually. Of these, approximately 10–20% are myocardial infarctions (MI).

Hypothesis: Patients with chest pain whose initial electrocardiogram (ECG) is normal do not require hospital admission for evaluation and management of a possible myocardial infarction.

Methods: The medical records of a consecutive cohort of 250 patients who presented to the ED with chest pain and were admitted by the ED physician to a cardiology inpatient service of an academic tertiary care medical center were reviewed. Reasons for admission to hospital was to rule out an acute coronary syndrome, specifically, myocardial infarction. The initial ECG of each patient was evaluated for abnormalities and compared with the final diagnosis.

Results: Of the 75 patients presenting with normal ECGs (normal, upright T waves and isoelectric ST segments), 1 (1.3%) was subsequently diagnosed with a myocardial infarction by Troponin I elevation alone. Of the 55 patients presenting with abnormal ECGs but no clear evidence of ischemia [i.e., left bundle branch block (LBBB), right bundle branch block (RBBB), left anterior hemiblock (LAH)], 2 (3.6%) were diagnosed with MI. Of the 48 patients presenting with abnormal ECGs questionable for ischemia (nonspecific ST and T wave changes that were not clearly ST segment elevation or depression), 7 (14.6%) were diagnosed with an MI. Of the 72 patients who presented with abnormal ECGs showing ischemia (acute ST segment elevation and/or depression), 39 (54.2%) were shown to have evidence for MI.

Summary: Patients who presented with normal ECGs (category 1) were extremely low risk for acute myocardial infarction. Patients with abnormal ECGs but no evidence of definite ischemia (category 2) had a relatively low incidence of MI. Patients with abnormal ECGs questionable for ischemia (category 3) had an intermediate risk of acute myocardial infarction. The majority of patients with abnormal ECGs demonstrating ischemia (category 4) were subsequently shown to evolve an acute myocardial infarction.

Conclusions: Patients with chest pain and initial ECGs with ST segment abnormalities suggestive or diagnostic for ischemia, should be admitted to the hospital for further evaluation and management. Patients with ECGs that do not display acute ST segment changes are at a lower risk for acute myocardial infarction than those with acute ST segment changes and should be admitted on the basis of cardiac risk profile. (i.e., age, gender, hypertension, diabetes, smoking, known coronary artery disease, etc.) Patients with normal ECGs (category 1) are at extremely low risk, and it may be acceptable to consider further evaluation on an outpatient basis.

Key words: electrocardiogram, chest pain, acute myocardial infarction, hospital admission

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Introduction

The evaluation of patients with chest pain is responsible for millions of Emergency Department (ED) visits

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and hospital admissions annually in the United States. Of these, approximately 10–20% of patients are eventually diagnosed with myocardial infarction (MI).[1–3] Thus a high percentage of patients are admitted who may not require in patient evaluation and management. Because of the high risk of significant morbidity and mortality associated with MI, and the effectiveness of current therapies in modifying this risk, early and accurate diagnosis with prompt treatment is essential. Therefore, the health care community has emphasized to patients and to health care workers the importance of early presentation for evaluation. Subsequently many patients are admitted to hospitals "to rule out myocardial infarction", often because of fear of missing a diagnosis of an MI.[4] Lee et al. found that 98% of patients with MIs were admitted to the hospital. This high sensitivity is thought to have been achieved only by admitting many patients with relatively low-risk for an MI.[5] While hospital evaluation and management is extremely important for patients who have an acute coronary syndrome or MI and thus are at high risk for adverse cardiac events, hospitalization of low risk patients may be unnecessary and may contribute to overburdening already-stressed health care resources. Effective utilization, interpretation, and implementation of clinical pathways, diagnostic testing modalities, and decision-making tools may contribute to more accurate diagnosis and risk stratification, thus allowing physicians to make better decisions regarding the need for hospitalization of patients presenting with chest pain and allowing them to be less fearful about the option for outpatient evaluation and treatment strategies. However, all other diagnostic testing, (e.g., nuclear, echo, CT angiography) increase the cost and still may not identify the high risk patient.

Emergency room ECG have been used to identify patients who are at low risk for complications[6] as well as those at higher risk.[7] This pilot investigation assesses the usefulness of the inexpensive ECGs to identify patients that may or may not need admission to the hospital. Thus, the purpose of this report was to identify patients who evolved an acute MI during hospitalization and relate that to the admission ECG. Morbidity, such as ventricular tachycardia, ventricular fibrillation, etc. either short-term or long-term was not assessed. The ultimate goal of the investigation was to find out which chest pain patients could be safely sent home from the ED based on their initial electrocardiographic findings.

Methods

After approval by the institutional review board, medical records of 258 consecutive patients over a two-year period admitted by the ED physician to the cardiology teaching service of the University of Florida/Shands Hospital for evaluation of chest pain were reviewed. Eight patients were removed from the cohort secondary to incomplete or unavailable medical records. The relatively short two-year time frame for collection of data makes it highly unlikely that therapy changed dramatically over the two-year period.

Only the initial interpretable ECG recorded in the ED was evaluated. Staff cardiologists blinded to the history and final discharge diagnosis of the patients interpreted the ECGs. The ECGs were then stratified into four categories.

Electrocardiogram Categories

Category 1 consists of a "normal" electrocardiogram with upright T waves, isoelectric ST segments, and no Q waves. Category 1 ECGs include normal sinus rhythm, sinus tachycardia, sinus bradycardia, premature atrial contractions and premature ventricular contractions.

Category 2 consists of abnormal ECG with no clear evidence of ischemia. For example, heart block, Left Bundle Branch Block (LBBB), Right Bundle Branch Block (RBBB), atrial fibrillation, paced rhythm, supraventricular tachycardia, left axis deviation, and left ventricular hypertrophy.

Category 3 consists of an abnormal electrocardiogram with changes questionable for ischemia. These ECGs questionable for ischemia are defined as nonspecific ST segment and T wave changes, ST elevation/depression in single leads or $\leq$0.1 mV, and Q waves $<$25% the height of the subsequent R wave.

Category 4 consists of an abnormal electrocardiogram showing evidence of ischemia, (i.e., transient or permanent ST segment elevation) or depression $\geq$ 0.1 mV in two contiguous leads and q waves that are greater than 25% of the height of the subsequent R wave.

Diagnosis of Acute Myocardial Infarction

The diagnosis of MI was determined by abnormal serum levels of cardiac markers including creatine kinase, creatine kinase-MB, and troponin I and/or by the presence of occlusive coronary artery disease demonstrated by coronary angiography that was felt to be acute.

Results

Table I summarizes patient demographics. Of the 250 patients whose medical records were reviewed, 49 (19.6%) were subsequently diagnosed with an acute MI. No distinction was made between ST-elevation and nonST-elevation MI. Of the remaining 201 patients (Table II), 39 were diagnosed with a definite or probable cardiovascular cause of their chest pain: 29 unstable angina, 4 stable angina, 2 myocardial ischemia due to cocaine use, 2 pericarditis, 1 hypertensive crisis, and 1 aortic aneurysm. Thirty-one patients had a noncardiovascular diagnosis as the etiology of their chest pain: 13 gastrointestinal, 8 musculoskeletal, 5 respiratory, and 5 anxiety. Over half of the patients (131, 52.4%) had a discharge diagnosis of chest pain of uncertain etiology, with no evidence of MI or ischemia detected during hospitalization.

TABLE 1 Patient demographics

Mean age	55 years old
Gender	Male 126 (50.4%) Female 124 (49.6%)
Race	Black 43 White 202 Hispanic 4 Asian 1
Known history of CAD	108 Patients
Diabetes	53 Patients
Hypertensive on admission	117 Hypertensive
Hyperlipidemia	101 Patients
Smoker	151 Patients
Family History of CAD	77 Patients

TABLE 2 Etiology of chest pain in patients not diagnosed as an MI

Diagnosis	Number of patients
Unstable angina	29
Stable angina	04
Cocaine use	02
Pericarditis	02
Hypertensive crisis	01
Aortic aneurysm	01
Gastrointestinal	13
Musculoskeletal	08
Respiratory	05
Anxiety reaction	05
CP of uncertain etiology, not MI	131

The number of patients in each ECG category are as follows: Seventy-five patients (30%) had Category 1 (normal) ECGs. Fifty-five patients (22%) had Category 2 ECGs (abnormal without evidence of ischemia). Forty-eight patients (19.2%) had Category 3 ECGs (abnormal questionable for ischemia). Seventy-two patients (28.8%) had Category 4 ECGs (abnormal with evidence of ischemia).

Table III demonstrates the number of patients in each category who did and did not evolve an MI during hospitalization. Of the 75 patients who presented with normal ECG (Category 1) 1 (1.3%) patient was subsequently shown to evolve an MI by cardiac enzymes only; echocardiography and cardiac catheterization were normal. Of the 55 patients with abnormal ECGs without evidence of ischemia (Category 2) 2 (3.6%) evolved an MI. Of the 48 patients presenting with abnormal ECGs questionable for ischemia (nonspecific ST and T wave changes that were not clearly ST segment elevation or depression), 7 (14.6%) were diagnosed with an MI. This difference is not statistically significant because of small numbers of patients, but the trend suggests a possible difference in this pilot investigation. Of the 72 patients who presented with abnormal ECGs showing ischemia (acute ST segment elevation and/or depression), 39 (54.2%) were shown to evolve an MI during the initial hospitalization.

TABLE 3 Number of patients in each ECG category who did and did not evolve a myocardial infarction during hospitalization

Electrocardiogram category	Acute myocardial infarction	No Acute myocardial infarction
Category 1 (Normal)	1 (1.3%)	74 (98.7%)
Category 2 (Abnormal without evidence of ischemia)	2 (3.6%)	53 (96.4%)
Category 3 (Abnormal questionable for ischemia)	7 (14.6%)	41 (85.4%)
Category 4 (Abnormal with evidence of ischemia)	39 (54.2%)	33 (45.8%)

Discussion

The decision to admit a patient to the hospital in which the diagnosis of MI is suspected is based on the anticipation of providing proper management and prolonging survival of the patient should they evolve an MI. This practice has led to large numbers of admissions of patients with chest pain to inpatient services. Several reports have indicated that the prevalence of MI in patients admitted to "rule out" an MI is relatively low between 14% and 24%.[2,3] Certainly some of these patients admitted for evaluation could have had an acute coronary syndrome, but our purpose was to define whether the patients had an acute MI, not to determine whether the chest pain was due to myocardial ischemia or other causes.

Category 1 Patients

The data presented here demonstrate that patients whose ECGs are normal have a very low risk of MI and can be safely triaged to out patient evaluation of their chest pain. Patients with normal ECGs have small risk of MI and likely have more benign disease courses. Triage of these patients in ED with observation and follow up cardiac stress testing could be an appropriate resource saving alternative to admission to a cardiac care unit. This is further supported by the findings of Koukkunen et al. in which patients were evaluated on the basis of history, clinical examination, ECG, and biochemical markers of myocardial injury and were either observed in the ER and discharged or admitted to the hospital. These investigators found that patients who were discharged directly from the ER or after observation in an adjacent chest pain observation unit had lower cardiovascular mortality at four weeks and 6 months compared with the patients admitted to inpatient services for suspected ACS.[8]

We cannot confirm these findings since we have no data on long term follow-up of our patients. Our follow-up was restricted to discharge from hospital of patients who did or did not have an MI.

Among our patients only one subject with a category 1, normal electrocardiogram evolved an MI diagnosed by an elevated troponin I. The patient had no wall motion abnormalities by echocardiography, ejection fraction was estimated at 60% and the patient had no demonstrable occlusive disease at coronary angiography. This single case of an individual with a category 1 electrocardiogram represents either a benign subclinical MI or a false positive.

In 1985, Brush and colleagues evaluated the initial ECG as a predictor of complications in 469 patients with suspected acute MI. An ECG was classified as positive if it showed evidence of ST segment elevation or Q waves on the ECG that were indicative of acute MI, and other ECG changes indicative of ischemia. These ECG changes include pathologic Q waves, ST segment elevation, ST segment depression, T wave inversion consistent with ischemia/injury or strain, left ventricular hypertrophy, LBBB, and paced rhythm. They also commented that normal or near normal ECG findings on admission are associated with a low risk of complications or bad outcomes. The serious complication rate was 0.6% among patients with normal ECGs compared with 14% among patients with abnormal findings.[9]

Perhaps the low incidence of MI in our category 1, normal electrocardiogram group is related to the strictness of the definition of "normal." No patient had any ST segment or T wave variations in any of the 12 leads of the ECGs.

Category 2 Patients

If changes such as ST segment elevation or depression were present only in one lead, the patient was considered Category 2, since changes such as these may represent possible recent ischemia that is resolving. Patients with category 2 ECGs are at higher risk for a subsequent MI than category 1 patients, but not all of these patients need hospitalization. However common sense would seem to indicate that those patients with multiple risk factors (i.e., hypertension, diabetes, previous revascularization procedures, smoking, tachyarrhythmias, or heart failure symptoms) warrant admission to hospital for further evaluation and management. Thus, the relatively low percentage of subsequent MI in patients with category 2 ECGs warrants admission on an individual basis.

Category 3 and 4 Patients

Data indicate that category 3 and 4 patients should be admitted to hospital for further evaluation and management because of the higher risk of subsequent acute MI.

Summary

Patients who presented with normal ECGs (category 1) were extremely low risk for earlyacute MI. Patients with abnormal ECGs but no evidence of definite ischemia (category 2) had a relatively low incidence of acute MI. Patients with abnormal ECGs questionable for ischemia (category 3) had an intermediate risk of acute MI. The majority of patients with abnormal ECGs demonstrating ischemia (category 4) were subsequently shown to evolve an acute MI.

Conclusions

1. Patients with normal ECGs (category 1) are at extremely low risk, and it may be acceptable to consider further evaluation on an out patient basis.
2. Patients with chest pain and initial ECGs with ST segment abnormalities suggestive or diagnostic for ischemia should be admitted to the hospital for further evaluation and management.
3. Patients with ECGs that do not display acute ST segment changes are at a lower risk for acute MI than those with acute ST segment changes and should be admitted on the basis of cardiac risk profile.
4. Patients who were admitted to hospital but did not have a documented MI may have myocardial ischemia as a cause of their chest pain. For that reason, they should be seen in follow-up to investigate that possibility using some form of stress to provoke ischemia, despite the lack of enzyme or biomarker changes of acute MI.

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