MYOCARDIAL INFARCTION WITH AN INITIALLY NORMAL ELECTROCARDIOGRAM

Medicine

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ABSTRACT

To analyze the paradox of acute myocardial infarction (AMI) with an initially normal electrocardiogram (ECG), we reviewed the records of 100 patients discharged with 21 final diagnosis of AMI over a 1-year period. Twentyone patient were identified whose initial ECG was normal and who underwent coronary arteriography during the index hospitalization.

According to the ECG evolution, three distinct groups were identified: Group 1: those who subsequently developed ST elevation or Q waves ($n = 7$), Group 2: those who developed ST depression or T-wave inversion ($n = 8$), and Group 3: those whose ECG remained normal ($n = 6$). Trop-T positive, Peak creatine kinase (CK), timing of the first ECG change, life threatening complications, and location of the infarct-related coronary lesion were recorded. Infarct-related coronary lesions were also classified into those in a major coronary trunk versus those in secondary branches. The incidence of AMI with a normal ECG was 3.7%. There was no difference in the frequency of coronary artery involvement in the groups studied: left anterior descending (33%), right coronary artery (38%), and circumflex (28%). All ECG changes developed within the first 48 h of hospitalization; 17 ± 15 h in Group 1, and 24 ± 12 h in Group 2. All six patients who had a persistently normal ECG (Group 3) had lesions in branch vessels ($p < 0.05$ when compared with Group 1 plus Group 2). Patients who developed ST elevation or Q waves (Group 1) always had a major artery trunk involved ($p < 0.05$ when compared with Group 2 plus Group 3). Patients in Group 3 had less myocardial damage and fewer complications compared with the other two groups. Myocardial infarction with an initial normal ECG is uncommon and may result from involvement of any of the three coronary arteries. Electrocardiographic evolution usually occurs within the first 48 h of hospitalization. Patients whose ECGs remain normal appear to have culprit lesions in coronary branches, smaller infarctions, and fewer in-hospital complications.

KEYWORDS

myocardial infarction, electrocardiogram, coronary arteries

INTRODUCTION

Patients presenting to emergency departments with a complaint of chest pain and who ultimately have a myocardial infarction (MI) may have a normal initial electrocardiogram (ECG). The incidence of this phenomenon varies widely in the literature (from 3-16%).

The paradox of a normal ECG in the face of an acute myocardial infarction (AMI) might be explained in several ways.

If the MI is very small, the magnitude of ECG changes may be undetected. It has been suggested that, in some infarcts, at least 3% of the left ventricle must be involved for ECG changes to develop.

Second, a normal ECG in the face of a myocardial infarction may relate to its location. The traditional 12-lead ECG generously interrogates the anterior wall, apex, and inferior wall. Infarctions in the lateral and posterior segments of the left ventricle, however, are not directly interrogated by conventional ECGs. It has been estimated that up to 50% of infarctions in the left circumflex distribution may be normal electrocardiographically.

Additional ECG leads have been recommended by some to address this apparent deficiency in the conventional 12-lead tracing.

Finally, patients may present so early in the course of their MI that ECG disturbances are not yet apparent. Such patients are destined, often within a short time, to develop recognizable ECG abnormalities.

So that the phenomenon of AMI with a normal ECG could be understood better, we reviewed a total of 100 patient records with a final diagnosis of AMI and identified 27 with an initial normal ECG. Of these, 21 underwent coronary arteriography during the index hospitalization and represent the basis for this report. We address the relationship between ECG evolution and coronary artery findings and the clinical course.

MATERIAL AND METHODS

Present study was conducted at Medicine Department of Darbhanga Medical College and Hospital, Laheriasarai, Bihar over a period of one year.

The records of 27 patients admitted through the emergency department who had an AMI confirmed by Trop-T positive, a typical rise and fall of creatine kinase, with an MB fraction $\geq 5\%$ and an initially normal ECG, were selected for further evaluation.

During the index hospitalization (3 to 7 days after admission), 21 of these patients underwent coronary arteriography and left ventriculography and form the basis of the present study.

Electrocardiographic Data

For the purpose of the study, normal ECGs included those with (1) nonspecific ST- or T wave abnormalities such as flattened T waves or < 0.1 mv ST depression, or early repolarization pattern, and (2) other nonischemic abnormalities such as left or right atrial enlargement or first-degree heart block. Serial ECGs recorded during the hospitalization were analyzed individually according to a modification of the Minnesota code. ST-segment elevation was considered significant if the J point was elevated > 1 mm and the ST segment remained elevated > 0.08 s beyond the J point.

Q waves were considered pathologic if the Q/R amplitude ratio was $1/3$ or more for leads other than aVF, plus a duration of ≥ 40 ms. Significant ST/T changes were defined as J point depression > 1 mm below the baseline or new T-wave inversion in two consecutive leads.

Patients were further classified according to ECG evolution into three groups: Group 1-patients who developed ST elevation or new Q waves, Group 2-patients who developed ST depression or T-wave inversion, and Group 3-patients with a persistently normal ECG.

Clinical Data

The medical records of these 21 patients, including the initial and final ECG, were reviewed. If an ECG change occurred during hospitalization, the first tracing demonstrating such change was also analyzed. The time from admission to the first abnormal ECG tracing, if present, abnormal creatine kinase, and peak creatine kinase values were recorded (Table I). All patients had abnormal levels of creatine kinase-MB fraction.

Also recorded were life-threatening complications (LTC), which were defined as: (1) ventricular fibrillation or asystole; (2) ventricular tachycardia causing loss of consciousness, lasting more than 29 s or requiring electrical or chemical cardioversion therapy; (3) atrial fibrillation, atrial flutter, or supraventricular tachycardia causing a systolic blood pressure ≤ 90 mm of mercury; (4) bradyarrhythmias requiring treatment with atropine or temporary pacing; (5) shock (systolic blood pressure ≤ 90 mm of mercury) requiring the use of vasopressors; (6) pulmonary edema documented by chest x-ray.

Table I : Clinical Findings By Group

	Group 1	Group 2	Group 3	*Overall groups test statistic	df	p-value
No. of patients	7	8	6		-	
Hours since pain onset	2.5 (1.44)	2.4 (2.01)	3.58 (2.26)	1.36	2	0.51 (NS)
MI confirmed (h)	16.6 (16.95)	14.8 (17)	7.9 (8.15)	1.12	-	0.57 (NS)
Time for ECG change (h)	17 (15.74)	24.4 (12.24)		1.61	-	0.20 (NS)
Peak CK	1488 (1478) ^b	728 (890)	286 (68) ^a	9.09	-	0.01
L.T.C.	4 (66%) ^b	2 (33%)	0 (0%) ^a	5.25	2	0.07*

*Nonparametric median test for continuous variables, chi-square test of independency for categorical variables.

^aDiffers from Group 1, pairwise comparison. $p < 0.05$ using Fisher's exact test.

^bDiffers from Group 3, pairwise comparison. $p < 0.05$ using Fisher's exact test.

Abbreviations : MI = myocardial infarction, CK = creatine kinase, df = degrees of freedom, L.T.C. = life-threatening complications, ECG = electrocardiogram, NS = Not Significant

Angiographic Data

The angiographic films were reviewed by observer blinded to the clinical and ECG data. Left ventricular systolic function and degree of coronary stenosis were estimated from the non-enhanced cineangiogram.

Coronary arterial segments were defined according to the CASS study. The diagnosis of coronary artery stenosis was made when a luminal diameter of $>50\%$ was present in any projection, and multivessel disease when stenosis was present in two or more major epicardial vessels or their branches.

An attempt was made in all cases to identify the infarct-related (culprit) coronary lesion. In patients with multivessel disease, assessment was made based upon the severity of the stenosis, the characteristic of the lesion (contrast avidity, filling defects, eccentricity, or scalloped borders), and the relationship to the wall motion abnormality.

For the purpose of our analysis, major coronary arteries were defined as: (1) the left anterior descending (LAD), from its origin to the apex; (2) the left circumflex (LCx), from its origin up to the takeoff of the second marginal branch; and (3) the right coronary artery (RCA), from its ostium up to the takeoff of the posterior descending.

Branch vessels were defined as diagonal branches from the LAD, obtuse marginals, and posterior descending branches from the LCx, and posterolateral or posterior descending branches from the RCA.

Statistical Methods

Descriptive statistics were generated for all continuous and categorical variables. This included means, medians, modes, standard deviations, and tests for normality on continuous level data. For categorical data percentages were calculated.

Descriptive statistics were generated for the entire sample and by group stratification. Non parametric inferential tests of significance were done for continuous level group data using Kniskal-Wallis (3-group) and Wilcoxon rank sum (2-group and pairwise) procedures. Chi-square tests of independence were used for categorical level 3-group data. For pairwise comparisons of two of 3-group data, Fisher's exact tests were performed because of cell sizes less than five.

RESULTS

Demographic and Clinical Evolution

Of the 100 patients screened, 27 were found to have an initially normal ECG in the emergency room (incidence = 3.7%).

Of these 21 had a coronary angiogram during the index hospitalization and formed our study group. Clinical and angiographic characteristics of this cohort are shown in Table II. The mean age was 54 ± 8 . All were Caucasian, 80% were males, and 10% had a history of previous MI.

Seven of the 21 patients (33%) developed ST elevation or new Q waves (Group I), 8 (38%) developed ST or T changes (Group 2), and 6 (28%) had a persistently normal ECG (Group 3). All ECG changes in Groups 1 and 2 were seen within the first 48 h of hospitalization.

The mean time of presentation to the emergency department after the onset of pain was 3.3 & 2.5 h. The time to the first abnormal creatine kinase value was not significantly longer in Group 1 compared with Groups 2 and 3 ($p = 0.51$). Group 3 had lower peak creatine kinase value compared with the other two groups ($p = 0.01$) (Table I).

Table II : Baseline Clinical And Angiographic Characteristics (n=21)

	Number of Patients (%)
Sex (Male)	19 (80)
Clinical History	2 (9)
• Previous myocardial infarction	8 (38)
• Hypertension	3 (14)
• Diabetes	
Angiogram	9 (43)
• Multivessel	17 (81)
• Right dominant	
Total	21

Angiographic Findings

A culprit lesion was identified in all 21 cases (Fig. 1). Of these, 33% were located in the LAD, 38% in the RCA, and 28% in the LCx distributions (Fig. 2). Single-vessel disease was present in 57% of the patients, and 80% had a right dominant coronary system. ECG evolution according to lesion locations showed that 57% of the patients with an LAD lesion developed an injury pattern and 28% had a persistently normal ECG, whereas 50% of the patients with circumflex lesions had a persistently normal ECG.

Of the six patients who had a persistently normal ECG, only three had culprit lesions in the LCx distribution ($p = 0.29$ when complex with LAD plus RCA).

When the lesions were categorized according to location in major coronary arteries or peripheral branches, all patients in Group 1, six of eight in Group 2 had culprit lesions in major coronary arteries, while all those in Group 3 had all culprit lesions in peripheral branches (Table III).

Life-Threatening Complications

Six patients in Groups 1 and 2, but no patient in Group 3 developed life-threatening complications ($p = 0.07$, when Group 1 is compared with Group 3) (Table II).

Fig. 1 Distribution of culprit lesions in 21 patients studied. 0 = Lesions

in secondary branches, A= lesions in major coronarytrunks. RCA = right coronary artery, LAD = left anterior descending,LCx = left circumflex artery.

Fig.2 Coronary involvement in patients with AMI and an initially normal ECG (n = 21). Patients with AMI and an initially normal ECG may have lesions in any of the three coronary arteries. LAD =left anterior descending, RCA = right coronary artery, LCx =left circumflex artery.

DISCUSSION

Electrocardiography is very commonly utilized in the evaluation of patients presenting to the emergency departments and suspected of having AMI. The initial ECG had been widely used to determine the likelihood of the presence of AMI and whether admission to an intensive care or a step-down unit is more appropriate. A normal initial tracing is associated with a very low likelihood of AMI and low risk for in-hospital complication. The 3.7% prevalence of a normal initial ECG in our cohort of patients with proven AMI is consistent with the findings of other investigators.

Our study demonstrates that 15 of 21 (71 %) patients presenting to the emergency room with an MI and an initially normal ECG developed ECG changes within the first 48 h of their hospitalization. It is possible that ECG changes would have been recognized earlier had tracings been obtained with greater frequency. Those patients who have a persistently normal ECG have the following features in common: (1) small MIS based on low creatine kinase peaks, (2) infarct-related lesions in peripheral coronary branches, and (3) an uncomplicated hospital course. While coronary lesions in this group were most commonly seen in the circumflex distribution, this trend did not reach statistical significance in comparison with the groups with ECG changes. The small number of patients studied may, however, have produced a type II statistical error. Of the entire group of patients presenting with an MI and an initially normal ECG, the infarct-related coronary lesions were nearly evenly distributed in the LAD, LCx, and RCA systems.

The mean time from onset of chest pain to the emergency room evaluation was 3.5 h. This time is similar to that reported in several thrombolytic trials where ECG abnormalities were a requirement for inclusion. Consequently, the initially normal ECG cannot necessarily be attributed to an early presentation.

At the same time, patients who developed ECG changes (Groups 1 and 2) had longer hospital intervals to the time of the first abnormal creatine kinase level, supporting the concept that some patients presenting to the emergency department with ischemic chest pain and a normal ECG are actually preinfarctional at that instant. In summary, our data suggest that anyone of several mechanisms may account for a normal initial ECG tracing in the presence of AMI.

Contrary to previous reports, we found that the life threatening complications occurred in 30% of patients with an AMI and a normal initial ECG and were only observed in patients developing ECG changes (66% in Group 1 and 33% in Group 2).

Electrocardiographic criteria used to describe a “negative” ECG in these earlier studies¹, included abnormal patterns with greater likelihood of ischemia compared with the more strictly normal patterns as defined in the current study. One might expect, therefore, that our cohort of patients would have experienced a lower frequency of life-threatening complications than those previously reported. On the other hand, both previous studies were composed largely of patients in whom AMI was excluded. All patients in Group 3 had culprit lesions in

peripheral coronary branches and had smaller MIS. They also had an uncomplicated hospital course although this did not reach statistical significance when compared with Group 1 (p = 0.07).

Our data support the concept that any one of several mechanisms may account in a given patient for a normal initial ECG tracing in the presence of documented myocardial infarction.

We also show that ECG evolution may occur within the first 48 h of hospitalization and emphasize a new classification for the location of coronary lesions as an important factor to explain the absence of electrocardiographic abnormalities in this particular setting.

CONCLUSION

We have identified and studied an unusual group of patients with AMI who presented initially with a normal ECG. Lesions in any of the three coronary arteries may be responsible for this presentation. Lack of ECG evolution over the first 48 h identifies a subgroup of patients that have smaller infarctions and fewer in-hospital complications.

During the following 48 h, ECG and clinical evolution appear to depend on the site of the infarct-related coronary lesion.

Patients that evolve the changes of a Q-wave MI are more likely to have major coronary trunk lesions in any of the three coronary arteries, whereas patients who remain without electrocardiographic changes may still have lesions in any of the three coronary arteries distribution, but the lesion would be in a branch.

Our study suggests that a persistently normal ECG in the face of an AMI defines a particular low-risk group with small myocardial infarctions, infarct-related lesions in peripheral coronary branches, and a low rate of in-hospital complications.

These observations support a conservative management approach for this group. A large majority of patients with AMI exhibiting an initially normal ECG will evolve ECG changes within the first 48 h of hospitalization. If ECG changes evolve, in-hospital complications are common (6 of 15 patients). This suggests that some patients admitted to step-down units or triaged to rapid “rule out myocardial infarction” protocols will require subsequent transfer to an intensive care setting. Larger studies are needed to confirm this preliminary observation about lesion location and prognosis of patients with AMI and an initially normal ECG.

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