# Contrast between Magnetocardiography and Electrocardiography for the Early Diagnosis of Coronary Artery Disease in Patients with Acute Chest Pain

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## Abstract

*Accurate identification of patients with acute coronary syndrome (ACS) is often difficult especially when an electrocardiogram (ECG) does not show typical changes of ST segment. The aim of the present study was therefore to investigate the sensitivity of magnetocardiography (MCG) and electrocardiogram for the early diagnosis of coronary artery disease in patient presenting with acute chest pain. Methods and Results: 287 patients with the suspected ACS with (144 patients) and without (143 patients) ST segment elevation were selected, The MCG recordings were obtained using a MCG system in a magnetically shielded room, and the ECG data were recorded by a ECG system. Ventricular repolarisation measurements including QRS-, R-, T-wave, and ST-T period from MCG were evaluated to determine the clinical relevance of these measurements compared with ECG. All patients underwent coronary angiogram examinations and patients with coronary artery narrowing $\geqslant$ 70% in at least 1-vessel were defined as CAD group. Result: The presence of significant CAD was identified with a sensitivity of 88.9% and a specificity of 73.2% on MCG, compared to 63.2% and 75.2% on ECG. Conclusion: MCG was acceptably sensitive and specific in identifying patients with ACS even in the absence of specific findings on ECG. Thus, MCG has potential clinical application for detection of ACS and should be further investigated.*

## 1. Introduction

Although there are various clinical diagnostic approaches and treatments, the rates of readmission in acute coronary syndrome (ACS) remain very high. Accurate identification of patients with acute coronary syndrome is often difficult especially when the electrocardiogram (ECG) does not show typical changes of ST segment [1]. In clinical work, the clinical manifestations, electrocardiographical and biochemical data were used to assess the risk of disease in patients presenting with acute chest pain [2]. In the current, coronary angiography is the most widely used means to confirm the clinical diagnosis, and then, percutaneous coronary intervention or coronary artery bypass graft is considered depending on the severity of coronary stenosis. Coronary angiography is limited in clinical application because of it's invasive methods, and with a relatively high surgical risk and high costs. Therefore, to find a non-invasive, economical, accurate detection method is to become the urgent needs of clinicians. Magnetocardiography (MCG) has been proposed as a non-invasive and contact-free technique for functional diagnosis of the coronary artery disease [3]. Electrocardiography (ECG) is a biological signal recorded in the current activities associated with the myocardial cell excitability. MCG records the magnetic field induced by the same bioelectric currents recorded on ECG [4]. The aim of the present study was therefore to investigate the sensitivity and specificity of MCG and ECG for the early diagnosis of coronary artery disease in patient presenting with acute chest pain.

## 2. Methods

### 2.1. Patient population

In this study, 287 consecutive patients, who were admitted to the Departments of Cardiology in 309 Hospital of PLA with suspected ACS between May 2008 and April 2010, were enrolled. Exclusion criteria were suspected variant angina, persistent ST elevation, any specific abnormalities of bundle branch block, atrial fibrillation, arrhythmia on ECG or left ventricular hypertrophy on echocardiography [5].

All the selected patients undergo the examination of ECG first, according to the results of ECG, the selected patients were divided into the positive group (E-P) and the negative group (E-N). Here an ECG was defined as positive in the case of pathologic Q wave, amplitude of ST depression $\geq$0.05 mV or T inversion $\geq$0.2 mV[6]. And then, all the selected patients undergo the examination of MCG after the examination of ECG, according to the results of ECG, the selected patients were also divided into two groups, the positive group(M-P) and the negative

group(M-N). The positive diagnostic criteria of MCG were defined as statements below. After both the examination of ECG and MCG, all patients underwent coronary angiogram examinations and patients with coronary artery stenosis ≥70% in at least 1-vessel of 16 segments in the 3 major coronary arteries and their branches, were defined as CAD group.

## 2.2. MCG examination

MCG was recorded in the resting state using a 9-channel MCG system (CMI company, USA) inside a magnetically shielded room[7]. The diagnostic criteria of MCG were based on the three major MCG parameters and the morphology of MCG maps. MCG parameters include the pre-peak repolarization (angle, trajectory and angular deviation), the post-peak repolarization (angle, trajectory and angular deviation) and the pre-post angle change. MCG maps include the number of positive and negative magnetic pole, the shape of magnet wire around the positive and negative magnetic pole. After baseline correction, the averaged signals were analyzed using the software of CardioMag Imaging Inc.

## 2.3. Statistical analysis

Analysis Data are expressed as mean ± SD for continuous variables, or as percentages for categorical variables. For the angular parameter, the mean was calculated as the inverse tangent of the mean of the cosines and singes of each angle. Sensitivity and specificity were determined in comparison between the CAD group. Statistical significance was defined as $P<0.05$.

# 3. Result

## 3.1. ECG

As a result of ECG, 144 out of 283 patients show typical changes of ST-T periods (as criteria described in method), and were predicted to positive group in ECG (E-P) (table1). At the same time,143 out of 283 patients dose not show typical changes of ST-T periods, and were predicted to negative group in ECG (E-N) (table1) . Among the 144 patients in E-P group, 120 patients were confirmed to have the severe coronary artery stenosis ≥70% by coronary angiogram, Among the 143 patients in E-N group, 73 patients were confirmed to have no severe coronary artery stenosis ≥70%. According to these data, the sensitivity and specificity in ECG is 63.2% and 75.2%, respectively (figure1).

## 3.2. MCG

As a result of MCG, 210 out of 283 patients were predicted as having CAD, and were classified as positive group in MCG (M-P). At the same time,77 out of 283 patients were predicted as having no CAD, and were classified to negative group in MCG (M-N) (table1). Among the 195 patients in M-P group, 169 patients were confirmed to have the severe coronary artery stenosis ≥70% by coronary angiogram, Among the 92 patients in E-N group, 21 patients were confirmed to have no severe coronary artery stenosis ≥70%. According to these data, the sensitivity and specificity in MCG is 88.9% and 73.2%, respectively (figure1).

The sensitivity and specificity of ECG and MCG in figure1 show that, the sensitivity of MCG was significantly higher than that of in ECG (88.9% vs.63.2%). There were no significant difference of the specificity between MCG and ECG (73.2% vs.75.2%).

Table 1. The examination result of ECG, MCG and coronary angiogram.

| | ECG | MCG | Coronaryangiogram |
|---|---|---|---|
| positive | 144 | 195 | 190 |
| negative | 143 | 92 | 97 |
| Total | 287 | 287 | 287 |

ECG: electrocardiogram; MCG: Magnetocardiography.

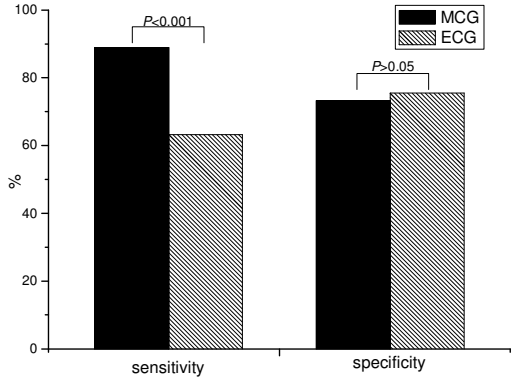


Figure 1.The sensitivity and specificity of ECG and MCG. ECG: electrocardiogram; MCG: Magnetocardiography.

# 4. Discussion

The purpose of the present study was to compare the sensitivity and specificity of ECG and MCG for the early diagnosis of coronary artery disease in patient presenting with acute chest pain. The key findings of this study are as follows: 1) the sensitivity of MCG was significantly higher than that of in ECG; 2) Both MCG and ECG were able to discriminate between normal and cardiac groups. However, MCG had the greatest discriminating power. The findings of the present study on sensitivity and

specificity of ECG and MCG are in agreement with the previous study [8-9]. Other study indicates that the number of channels was required to give a consistent estimate of dispersion, approximately 25 channels was the minimum number necessary to identify the differences detected in this study [8]. In the present study, we use a 9-channel MCG system. This may be one of the reasons for the inconsistency of the data. Compared with ECG, MCG had distinctly higher sensitivity. This result shows that MCG may be useful to avoid the inadvertent discharge of the patient who truly has myocardial ischemia. However, Specific problem areas effecting the repolarisation interval measurement of MCGs arise from the biphasic shape of the end of the T-wave. In order to improve automatic analysis of these waveforms automatic algorithms were generated to reduce measurement uncertainty and variability in these signals [10]. In conclusion, our study showed that MCG has potential clinical application for detection of acute coronary syndrome and should be further investigated.

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