USEFULNESS OF A NOVEL THREE DIMENTIONAL ELECTROCARDIOGRAPHY SYSTERM IN PATIENTS WITH PRIOR MYOCARDIAL INFARCTION

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ABSTRACT

Introduction*: This study aims to understand the usefulness of a novel noninvasive 3-dimensional electrocardiography systerm (3D-ECG)in the diagnosis of prior myocardial infarction.*

Material and methods*: 212 patients with more than 1 month history of acute myocardial infarction were selected as prior myocardial infarction group(PMI). 88 patients without myocardial infarction were selected as control group(NPMI). Electrocardiograph and 3D-ECG were applied on all patients in order.*

Results*: Comparison between 3D-ECG and ECG was accomplished in 212 prior myocardial patients and 88 non myocardial patients. 3D-ECG correctly diagnosed prior myocardial infarction in 210 of 212 (99%)PMI and non myocardial infarction in 84 of 88 (95%) NPMI, while ECG diagnosed prior myocardial infarction in 132 of 212 (62%)PMI and non myocardial infarction in 84 of 88 (95%)NPMI. 3D-ECG misdiagnosed prior myocardial infarction in 2 of 212 (0.9%)PMI and non myocardial infarction in 4 of 88 (4.5%) NPMI,while ECG misdiagnosed prior myocardial infarction in 80 of 212 (37.7%)PMI and non myocardial infarction in 84 of 88 (4.5%)NPMI.*

Discussion*: The study shows a high success rate of 3D-ECG in accurately diagnosing the prior myocardial infarction comparing with ECG and its application to diagnose prior myocardial infarction is under the way.*

Keywords*: myocardial infarction, prior, 3-dimensional, Electrocardiography, 3D, ECG.*

DOI: 10.19193/0393-6384_2018_6_282

Received *March 30, 2018;* ***Accepted*** *June 20, 2018*

Introduction

12-lead electrocardiogram, a widely used noninvasive tool in clinical practice, is highly sensitive and specificin diagnosing acute myocardial infarction(1), but it has diagnostic limitations in diagnosing prior myocardial infarction(2-3), since the specific ST-T variation in the acute phase of myocardial infarction no longer exists. Reports indicate that about 80% of prior myocardial infarctions present no exact feathers of electrocardiogram and the diagnosis by ECG is easy to be missed(4). Correctly indentify the prior myocardial infarction diagnosis is of great significance for clinical practice to make treatment strategy and judge the prognosis, therefore, it is important to find out a more sensitive and specific diagnosis method.

3D-ECG is a novel noninvasive 3-dimensional electrocardiography system that records cardiac electric activities subsequent to the electrocardiogram and vectorcardiogram, and provides global mapping in a single beat. The objective of this study is to to evaluate the potential of this system in prior myocardial infarction.

Materials and methods

Research objects

212 patients with more than 1 month history of acute myocardial infarction were select as the prior myocardial infarction group(PMI), in which there were 169 male patients and 43 female patients with average age of 63±11. Among them, 119 patients have definite evidences of coronary

angiography. 88 patients without myocardial infarction were selected as control group, in which there were 43 male patients and 45 female patients, including 22 healthy persons (with exact coronary angiography or other exact diagnostic basis), 39 hypertension patients, 27 patients with stable angina pectoris (with exact coronary angiography or other exact diagnostic basis), 14 patients with Diabetes Mellitus and 1 patient with rheumatic heart valve disease (based on cardiac ultrasound). The patient with age ≤18 or urgent and danger diseases were excluded.

Instruments and methods

Paired design was selected as the research method. Electrocardiograph and 3-dimensional electrocardiograph were applied on all the selected patients in order, and then examination was carried out according to the instruction. 12 lead ECG and 3D-ECG were recorded, stored and printed.

12 channel digital electrocardiograph with auto-analysis produced by Fukuda Co., Ltd. (Japan) and 3D-ECG electrocardiograph produced by Beijing Cardis Medical Technology Co., Ltd. were applied.

Diagnostic criteria for prior myocardial infarction

The diagnosis of ECG was based on Minesota code, and prior myocardial infarction can be diagnosed when any of the following criteria was matched.

1) Q≥1/3R, Q≥0.04 s in any of leads I, II or V2-V6.

2) Q≥0.04 s in any of leads I, II or V2-V6.

3) Q≥0.04, R wave ≥0.3 mV in lead aVL.

4) Q≥0.05 s in lead III, aVL, while Q≥0.1 mV in lead aVF.

5) Q≥0.05 mV in lead aVF.

6) Q wave in leads V2-V6, while R wave in the adjacent right chest lead (lead V1 presented as rS pattern).

7) Leads V1-V4 presented as QS pattern or all leads V1-V6 presented as QS pattern.

The diagnostic criteria of 3D-ECG was listed as follows.

1) Anteroseptal myocardial infarction: No initial forward vector in QRS loop existed and 0.02 s QRS vector was directly backward.

2) Localized anterior myocardial infarction: Initial forward vector (interventricular septal vector) still existed, and 0.02 s QRS vector was directly backward, and voltage standards of left ventricular hypertrophy were not possessed.

3) Extensive anterior myocardial infarction: No initial forward vector in QRS loop accompanied by clockwise horizontal plane QRS loop.

3) Anterior and lateral myocardial infarction: Initial forward vector (interventricular septal vector) was normal; initial rightward vector > 0.022 s; centrifugal branches of horizontal plane QRS loop were clockwise; initial rightward vector > 0.16 mV; the maximum vector of frontal plane QRS loop > 400; QRS loop was counterclockwise.

5) High lateral myocardial infarction: The maximum vector of frontal plane QRS loop > 400, and QRS loop was counterclockwise; no specific variation of horizontal plane QRS loop.

6) Inferior myocardial infarction: initial QRS upward vector > 0.025 s or initial QRS upward vector ≥ 0.02 s, and the maximum leftward and upward vector ≥0.25 mV accompanied by the maximum vector of frontal plane QRS loop < 100, and the centrifugal branches of QRS loop were clockwise; "ventricular septal" existed in the returning branches of frontal plane QRS loop.

7) Inferior and lateral myocardial infarction: Initial rightward vector of QRS loop > 0.022 s; initial upward vector > 0.025 s; the centrifugal branches of frontal plane QRS loop were clockwise; initial rightward vector of QRS loop > 0.16 mV.

8) Posterior myocardial infarction: the anterior area of QRS loop > 70% of the total area; the maximum leftward vector of QRS loop was in front of +200; the time limit of QRS forward vector > 0.05 s; QRS half area vector was in front of +100; the maximum forward vector of QRS loop ≥0.6 mV.

Statistical analysis

Statistical analysis software SAS®[9.10] was applied for the data treatment and statistical analysis, and $\chi 2$ test was performed as the statistical method for paired enumeration data, and McNemar Test was applied. The difference with P≤0.05 was statistically significant.

Results

Sensitivity, specificity and accuracy of 3D-ECG and ECG on prior myocardial infarction

In PMI group, there were 210 positive cases (true positive) and 2 negative cases (false negative) in 3D-ECG, while 132 positive cases (true positive) and 80 negative cases (false negative) in ECG.

In NPMI group, there were 4 positive cases (false positive) and 84 negative cases (true negative) in 3D-ECG while 4 positive cases (false positive) and 84 negative cases (true negative) in ECG (Table 1).

	PMI group (N=212)		NPMI group (N=88)	
	True positive	False negative	False positive	True negative
ECG	132	80	4	84
	(62.26%)	-37.74%	-4.50%	-95.45%
3D-ECG	210	2	4	84
	-99.06%	-0.94%	-4.50%	-95.45%

Table 1: The sensitivity, specificity and accuracy of 3D-ECG and ECG on the diagnosis of prior myocardial infarction.

According to the following formulas: Sensitivity= true positive/(true positive + false negative), Specificity=true negative/(true negative + false positive) and Accuracy= (true positive + true negative)/total patients.

The sensitivities of 3D-ECG and ECG on the diagnosis of prior myocardial infarction were 99.06% and 62.26%, respectively, and the specificities of them were both 95.45%, and the accuracies were 98.00% and 72.00%, respectively.

Comparison between 3D-ECG and ECG on prior myocardial infarction

In 212 prior myocardial infarction, there were 132 positive cases and 2 negative cases in both ECG and 3D-ECG; there were 78 cases which were negative in ECG while positive in 3D-ECG, and in the contrary condition, there was none. In 88 cases of the control group, there were 81 negative cases and 1 positive cases in both ECG and 3D-ECG; there were 3 cases which were negative in ECG while positive in 3D-ECG, while in the contrary condition, there was 3 cases (Table 2).

	PMI group (N=212)		NPMI group (N=88)	
	ECG positive	ECG negative	ECG positive	ECG negative
3D-ECG positive	132	78	1	81
3D-ECG negative	0	2	3	3

Table 2: Diagnosis results on prior myocardial infarction by 3D-ECG and ECG.

The statistical analysis showed that the diagnostic sensitivities of 3D-ECG and ECG on prior myocardial infarction were 99.06% and 62.06%, respectively, and accordingly, $P<0.0001$; the specificities of them were both 95.45%, and accordingly $P=1.000$; the accuracies of them were 98.00% and 72.00%, respectively, and the $P<0.0001$ (Table 3).

It indicated the diagnosis sensitivity and accuracy of 3D-ECG on prior myocardial infarction were significantly higher than traditional 12-lead ECG, while the specificities of them were similar.

	ECG	3D-ECG	P value
Sensitivity	62.26%	99.06%	‹0.0001
Specificity	95.45%	95.45%	1
Accuracy	72.00%	98.00%	‹0.0001

Table 3: Ratio comparisons between 3D-ECG and ECG on diagnosis of prior myocardial infarction.

Security comparison between 3D-ECG and ECG.

Compared with ECG, there were no symptoms and signs in the record process of 3D-ECG, indicating the securities of both methods were good.

Discussions

The diagnosis on prior myocardial infarction by electrocardiogram is mainly based on the presence of abnormal Q wave2-4, however, it is influenced by a lot of factors. With the process of the disease, the abnormal Q wave may decrease or even disappear, moreover, the presence of Q wave is not definitely caused by myocardial infarction, while the similar variation can also exist in hypertrophic cardiomyopathy. Besides, several factors may result in high omission diagnostic rate and high misdiagnosis rate of prior myocardial infarction including the coverage of ventricular hypertrophy, abnormal intraventricular conduction, the presence of electrocardiogram blind zone and interaction or even cancellation of the depolarization vectors in different parts caused by multiple-site infarction. The research indicated that the sensitivity, specificity and accuracy of electrocardiogram on the diagnosis of prior myocardial infarction were only 61%, 89% and 75%, respectively[2]. In recent years, with the performance of reperfusion therapy in the early stage, more and more myocardial infarction cases without Q wave occurred, resulting in more and more false negative diagnosis by electrocardiogram.

The development of modern computer science makes it possible to perform 3-dimensional examination and record bioelectrical activities. 3D-ECG is a new method for bioelectrical activity record on such basis.

3D-ECG can scan 3-dimensional electrocardiogram vector loop and exhibit phase properties of the cardiac electrical activity using Frank corrected lead system, which makes the graph more intuitionistic and the visual angle more comprehensive to preferably reflect cardiac electrical activities and accordingly to explain the principles of electrocardiogram production and some cardiac electrical phenomena preferably. 3D-ECG5 can develop three plane electrocardiogram vector loops into a time-electrocardiogram vector graph using time as the abscissa.

It also can rotate two axial coordinates in 90° counterclockwise and then develop clockwise to preferably observe the density variation of initial lacrimal punctum and directly describe the maximum leftward and rightward space vector, and at the same time, it intensively develops the P-QRS-T wave from 3-dimensional space in a manner of transient lacrimal punctum to reveal the myocardial depolarization and repolarization characteristics of electrocardiogram vector loop in three planes, whose advantages are the cognition on the P, QRS, T and U waves.

The research indicated that the diagnostic values of 3D-ECG on preexcitation syndrome, bundle branch block and left ventricular hypertrophy were better than those of ECG6-10, however, it was still not clear whether the diagnostic value of 3D-ECG systerm on prior myocardial infarction was better than that of ECG.

Results in this paper indicated that the diagnostic sensitivity and accuracy of 3D-ECG systerm were as high as 99% and 98% respectively, while those of ECG were only 62% and 72%, the differences between the two were significant, indicating 3D-ECG is good than ECG in diagnose the prior myocardial infarction; the diagnostic specificity of the two methods on prior myocardial infarction were both 95.45%, indicating both of them had similar capacity to distinguish whether the patients suffered prior myocardial infarction or not. Moreover, no symptoms and signs occurred during the whole operation process of 3D-ECG, indicating the similar securities of 3D-ECG and ECG.

So, 3D-ECG systerm possessed not only good detection ability, namely, low omission diagnostic rate, but also high diagnostic accuracy, namely, low misdiagnosis rate. The advantages of 3D-ECG were obvious on prior myocardial infarction when compared with ECG. 3D-ECG could provide important clinical information to help the diagnosis, treatment and condition evaluation in time, especially in the situations that the medical history was unclear or it could not be diagnosed as prior myocardial infarction by ECG. From the discussions above, 3D-ECG is a good clinical examination method which can be use for the diagnosis and identification of prior myocardial infarction.

Conclusion

3D-ECG systerm is a novel noninvasive examination method which can be use in facilitating the diagnosis of prior myocardial infarction, decreasing misdiagnosis rate and omission diagnostic rate.

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