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SM Journal of Cardiology and Cardiovascular Diseases

Research Article

Amplitude of Inverted T-Waves in Arrhythmogenic Cardiomyopathy in Special Right Ventricular Leads

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Article Information

Received date: Aug 29, 2017
Accepted date: Sep 15, 2017
Published date: Sep 21, 2017

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Keywords Arrhythmogenic cardiomyopathy; Lead aVR; Lead V1; Amplitude of inverted T-waves

Abstract

Background: Arrhythmogenic cardiomyopathy is electrocardiographically characterized by right precordial T-wave inversions and epsilon waves as major criteria. Additionally, terminal activation delay of 55ms or more serves as a minor criterion. More and more evident are pathological data of right ventricles without dilatation or aneurysm, but typical fibrofatty abnormalities and myocardial atrophy. The ECG's of these patients lack right precordial T-wave inversion and epsilon waves. Lead aVR and lead V1 could become more and more relevant.

Method: 413 cases with arrhythmogenic cardiomyopathy (292 males, mean age 46.3 ± 11.6 years) and a collective of normal probands (1496 patients, 859 males with an age range of 18-81 years) was analyzed with regard to ECG appearance of lead aVR and the amplitude of inverted T-waves in lead V1.

Results: With a specificity of 99.9%, a positive predictive value of 99.7% and a negative predictive value of 98% lead V1 and aVR were most relevant to diagnose arrhythmogenic cardiomyopathy if an amplitude of Q waves of 3mm or more, R waves of 2mm or less, inverted T waves of 2mm or less in lead aVR and inverted T waves in lead V1 were present.

Conclusion: These two leads appear most relevant to make the diagnosis of arrhythmogenic cardiomyopathy even in cases without right ventricular dilatation and right ventricular aneurysms.

Introduction

According to a presentation of Christina Basso, leading pathologist at the University Hospital of Padua, Italy, during the symposium on Myocardial and Pericardial diseases, held in Warnemünde, Germany, in October 2017, right ventricular dilatation is lacking in rare cases with arrhythmogenic cardiomyopathy. Rarely, right ventricles present without dilatation, aneurysms and wall thinning, but the typical presentation of fibrofatty abnormalities with myocardial atrophy in a normally seized and thickened right ventricle. In all cases the ECG revealed no typical abnormalities like right precordial T-wave inversions or epsilon waves in right precordial leads, but a Q wave of 3mm or more, an R wave of 2mm or less and an inverted T wave with an amplitude of 2mm or less in lead aVR. Additionally, the amplitude of inverted T wave of lead V1 was 2mm or more. These two leads represent typical right ventricular ones.

Method

We analyzed the ECG's of 413 cases with arrhythmogenic cardiomyopathy (292 males, mean age 46.3 ± 11.6 years, patients of the Medical School Hannover, Municipal Hospitation Oldenburg, University Hospital of Magdeburg and Hospital of Quedlinburg, Harz Clinic of Goslar, and the St. Elisabeth Hospital Salzgitter-Bad, Germany, where the author worked from 1985 up to 2016) at a paper speed of 50mm/sec. Patients conferred retrospectively to diagnostic criteria published by Frank Marcus in 2010 [1]. As a control group served a collective of normal probands (n=1596, 859 males with an age range between 18 and 81 years) of the University Clinic of Glasgow, U.K. (Director of the Section Electrocardiography, Institute of Health and Wellbeing, Royal Infirmary Glasgow: Prof. Peter Macfarlane) at a paper speed of 25mm/sec. Measurements were made by Elaine Clark by the same institution in Glasgow. Although specificity of typical changes in lead aVR Q-wave >= 3mm,small R-wave <= 2mm and T-wave inversions) are, per se, moderate (81 and 86%, respectively), the addition of inverted T-waves of ? 2mm in lead aVR should be analyzed with regard to statistical values. As a last step, the amplitude of inverted T-waves in lead V1 of 2mm or more should be added.

For statistical analysis sensitivity, specificity, positive predictive value and negative predictive value were calculated.

Results

In 413 cases with arrhythmogenic cardiomyopathy (292 males, mean age 46.3 ± 11.6 years) epsilon waves in right precordial leads suggesting aneurysms in the right ventricular outflow tract

Figure 1: Typical appearance of lead aVR with the amplitude of T-waves of 2mm or less.

were detected in 95 cases (23%), T-wave inversions in right precordial leads were present in 227 cases (55%) and prolongation and epsilon waves- like abnormalities in inferior leads suggesting tricuspid-near inferior aneurysms were detected in 91 cases (22%). Dilatation of the right ventricle was not detected in 56 cases. At right ventricular angiography deep horizontal fissures in the right ventricular outflow tract could only be seen in 57 cases, whereas a mixture of deep horizontal fissures and bulgings were seen in the other cases. All patients were examined by ECG, transthoracic echocardiography, coronary angiography, left ventricular angiography and right ventricular angiography. Echocardiography revealed in all cases localised dilatation of the right ventricular outflow tract, right ventricular inflow tract, or bulging of the right ventricular apex published by Frank Marcus 2010 [1]. Magnetic resonance imaging was not performed in any cases. The ECG measurements in cases with arrhythmogenic cardiomyopathy were made by the author himselve, the measurements of normal probands were made by the Elaine Clark of the team of Prof. Macfarlane (Figure 1).

If lead aVR criteria of large Q waves of 3mm or more, small R waves of 2mm of less and negative T-waves in the Glasgow collective were combined to an amplitude of negative T-waves in lead aVR of 2mm or less and compared to data in arrhythmogenic cardiomyopathy sensitivity was 94%, specificity 97%, positive predictive value 88% and negative predictive value was 97%. These results were calculated elsewhere and published [2,3] (Figure 2).

If additionally combined to an amplitude of negative T-waves in lead V1 of 2mm or more the statistical analysis was as follows:

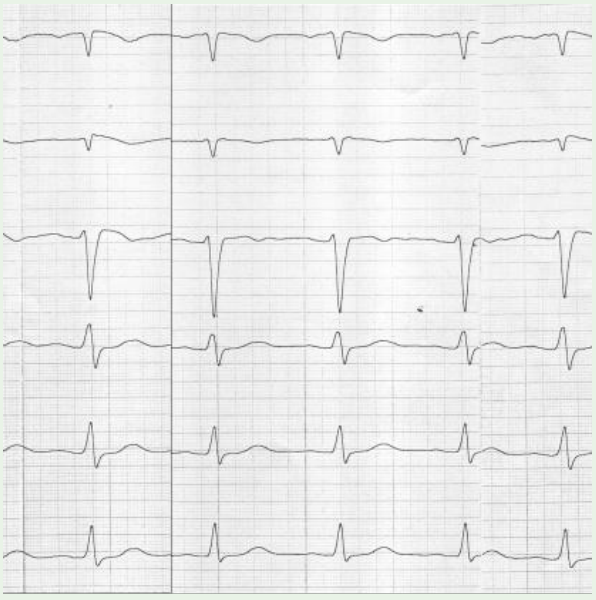

Figure 2: Amplitude of inverted T-waves in lead V1 of 2mm or more.

Table 1: ECG parameters in cases with ARVC and normal probands.

	Positive findings	Negative findings	
ARVC	n=385	n=28	413 (94%)
normal probands	n=49	n=1447	1496 (97%)
Amplitude inverted Twave >= 2mm in lead V1			
ARVC	n=385	n=28	41(94%)
Normal probands	n=1	n=1495	1496 (99.9%)

Note: Q wave >= 3mm, R wave <= 2mm and inverted T-wave in lead aVR + Amplitude of inverted T-wave <= 2mm in lead V1.

sensitivity 94%, specificity 99.9%, positive predictive value 99.7% and negative predictive value 98%. These results were calculated elsewhere and published [4] (Table 1).

Discussion

According to the results of the Glasgow collective the ECG of apparently normal hearts with a fibrofatty focus without right ventricular dilatation and without right ventricular aneurysms should be analyzed as follows:

With the two components of lead aVR (large Q waves of 3mm or more, R waves of 2mm or less [2] and an amplitude of negative T-waves of 2mm or less [3] sensitivity is 94%. These results can be further enhanced by analysis of the amplitude of negative T-waves of 2mm or more in lead V1 with a sensitivity of 97% [4]. An amplitude of inverted T waves of 2mm or more could be described in cases with unclassifiable arrhythmic cardiomyopathy associated with Emery-Dreifuss caused by a mutation in FHL with typical fibrolipomatosis of the right ventricle and hypertrabeculation of the left ventricle [5].

Nevertheless, right precordial T-waves inversions and epsilon waves are major ECG criteria of all types of arrhythmogenic cardiomyopathy and in cases with dilated right ventricles and right ventricular aneurysms.

In cases of arrhythmogenic cardiomyopathy without dilatation and aneurysms ECG analysis should be directed to the amplitude of inverted T-waves in lead V1 and its exclusion in lead aVR.

The simple means of standard ECG remains a relevant finding in the diagnosis of arrhythmogenic cardiomyopathy in spite of specific cardiac imaging techniques like nuclear magnetic resonance technique [6] or right ventricular angiography [7]. In the future, bipolar ECG, could be a technique, especially for lead V1, to improve outcomes [8].

In pathologic features of arrhythmogenic cardiomyopathy without right ventricular dilatation, wall thinning and aneurysms the ECG presents with highly typical features in lead aVR and lead V1. Epsilon waves and right precordial T wave inversions are major criteria of arrhythmogenic cardiomyopathy, but lead aVR and V1 are more relevant in cases without right ventricular dilatation and right ventricular aneurysms. In the present study lead aVR and V1 are far more sensitive than T-wave inversions in right precordial leads and epsilon waves in all types of arrhythmogenic cardiomyopathy.

Limitations

The only limitation of the study was the fact that cardiac MRI

Citation: Peters S. Amplitude of Inverted T-Waves in Arrhythmogenic Cardiomyopathy in Special Right Ventricular Leads. SM J Cardiolog and Cardiovasc Disord. 2017; 3(3): 1013s1.

was not used, as the patients were detected as having arrhythmogenic cardiomyopathy long ago from 1985 on where MRI technique was infrequently used. In fact, MRI in the present form is superior to echocardiography. Nevertheless, there are lot of centers who use right ventricular angiography and echocardiography instead of MRI technique.

There is definitely bias in the measurement of ARVC patients, but the same is true in the measurements in the control group.

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