VECTOR ELECTROCARDIOGRAPHY IN THE DIAGNOSTICS OF FOCAL CHANGES IN THE MYOCARDIUM

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Acute coronary disease diagnostics improvement is a worldwide priority. The introduction of a promising method of study of the electromotive force of the heart with the use of information technologies, allows us to diagnose acute myocardial infarction. We have used a modern cardiodiagnostics complex MTM-SKM by Severodonetsk Scientific Production Association "Microtherm" (Ukraine).

Clinical case. The presence of vectorcardiography necrobiotic processes in the left ventricle apical region, intraventricular conduction and hemodynamic overload of the atria has been revealed at the patient D., 59, with acute myocardial infarction, which was additional information that has not been registered on the ECG.

Conclusion. Vector electrocardiography, allows us to investigate the periodic distribution of the electromotive force in dynamics over the entire surface of the heart, and also makes it possible to obtain detailed information about the functional state of the myocardium, specifying the depth and extent of the pathological process.

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Key words: acute myocardial infarction, cardiodiagnostic complex MTM-SKM, vectorcardiography, thrombolytic therapy.

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ECG — electrocardiography, EMF/H — electromotive force of the heart, LV — left ventricle, MI — myocardial infarction, PCI — percutaneous coronary intervention, STEMI — ST elevation myocardial infarction.

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ВЕКТОРНАЯ ЭЛЕКТРОКАРДИОГРАФИЯ В ДИАГНОСТИКЕ ОЧАГОВЫХ ИЗМЕНЕНИЙ В МИОКАРДЕ

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Совершенствование диагностики острой коронарной патологии является приоритетной задачей во всем мире. Внедрение перспективного метода исследования электродвижущей силы сердца с использованием информационных технологий позволяет своевременно диагностировать острый инфаркт миокарда. Нами использован современный кардиодиагностический комплекс МТМ-СКМ Северодонецкого научно-производственного объединения "Микротерм" (Украина).

Клинический случай. Векторкардиографически выявлено наличие некробиотического процесса в верхушечной области левого желудочка, нарушение внутрижелудочковой проводимости и гемодинамическая перегрузка предсердий, что является дополнительной информацией, не зарегистрированной на ЭКГ.

Заключение. Векторная электрокардиография, позволяющая исследовать весь период распространения электродвижущей силы в динамике по всей поверхности сердца, дает возможность получить исчерпывающую информацию о функциональном состоянии миокарда с уточнением глубины и распространенности патологического процесса.

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Ключевые слова: острый инфаркт миокарда, кардиодиагностический комплекс МТМ-СКМ, векторкардиография, тромболитическая терапия.

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Introduction

Coronary heart disease is the most common cause of death in Europe, causing nearly 2 million deaths every year. Coronary artery pathology still cause death of approximately 17% of men aged 65 years and 12% of women of the same age [1]. In this regard, the introduction of new information technologies into acute coronary disease diagnostics is a priority in cardiology throughout the world, and the possibility to use the equipment at the bedside is an important component of a comprehensive diagnostic approach to patients. According to the Task Force of the European Society of Cardiology on the management of ST segment elevation myocardial infarction (MI) (2008), electrocardiography (ECG) plays a central role. However, in the case of questionable results of ECG, particularly in the early stages of a heart attack, it is necessary to conduct repeated ECG studies, electrotopogram registration, echocardiogram and evaluation of cardiac biomarkers levels with their ambiguous estimation due to their high sensitivity and low specificity [2]. Therefore, the use of innovative technologies will allow us to diagnose acute MI on time and with high accuracy.

A promising myocardial disease diagnostic method is vector ECG, which allows earlier detection of local changes in myocardial activity, provides more accurate diagnostics of focal myocardial changes regarding their location and extent. Also at heart attacks which are complicated by bundle-branch block, myocardial hypertrophy in both left and right ventricles, atria, their hemodynamic overload, and disruption of conduction. The interest in this technique is obvious, as shown by studies of electromotive force of the heart (EMF/H) in many countries of the world [3-7]. We have used a modern cardiodiagnostic complex MTM-SKM by Severodonetsk Scientific Production Association "Microtherm" (Ukraine), which allows the use of computer technology, from the first moments of patient monitoring with VCG-monitor, to

make an automatic calculation of parameters, to increase questionable sections of the loop route 3000 times. In addition, the precardial electrode placement by polyhedron method, consisting of five projections, increases information about EMF/H.

Vectorcardiogram (VCG), as well as the ECG, is a form of graphical representation of the invisible biophysical phenomenon. However, the ECG in a single abduction gives scalar performance of the size of waves and of the duration of cardiac cycle phases, while VCG displays the magnitude and the direction of the resultant electric field of the heart during each of its activities [8]. With this in mind, VCG — study not only complements but significantly expands data collected from 12 conventional ECG abductions. For this purpose, the location of the electrodes is in such points over the area of the heart, that the axis of their abductions could give an opportunity to observe and study the whole period of EMF spread in the dynamics on the entire surface of the heart, maximally eliminating the so-called "dead zones", namely: in abduction I — from the front of the chest; in abduction II — roughly from the left shoulder and somewhat backwards with the primary visibility of the postero-lateral region of the left ventricle; in abduction III — from the right lowerphrenic areas; in abduction IV the visibility of the top is possible and in abduction V — of the base of the heart (in its usual location) [9]. Herewith loops P, QRS and T of VCG match the waves of ECG.

VCG diagnostics of MI is based on identification of the pathological symptoms of two kinds: MI symptoms that can be detected in ECG abductions that form this VCG-abduction, and symptoms of myocardial infarction that only vectorcardiography can detect (actually VCG-symptoms of MI) [10].

The evaluation of the simultaneous changes in loops QRS and T is the basis of focal myocardial changes recognition. Unclosed QRS and T loops, as well as the displacement of ST ECG intervals indicate the presence of unbalanced electrical forces in the phase of depolarization to repolarization transition. The electric forces of damage vector is directed with its positive pole to the center of necrobiosis and is referred to as vector ST. T loop in acute MI may have normal size, and there may be a decrease in the angle of deviation of its direction towards the initial part of QRS route and even further. The shape of the loop T resembles a horseshoe.

The polarity in the system of five precardial projections is important to evaluate VCG. Changes in the QRS loop spatial orientation in the system of coordinates is the proof of MI localization. In acute MI, a sharp spatial displacement of QRS loop, and especially its initial part, from the region of localization of the heart attack in the opposite direction. In the case of MI, necrobiosis affecting separate or large areas of myocardium do not give their portion of normal electrical forces, therefore unbalanced opposing electrical forces of intact areas "drag" QRS loop in the opposite direction from the focal.

In the VCG analysis in the case of acute coronary pathology the direction of QRS loop route in each projection is of great importance as an indicator of normal or pathological spread of excitation on the myocardium: clockwise or counter-clockwise.

The beginning of local intraventricular block in acute MI may be manifested in the form of additional QRS loop areas or in a simple change in the direction or orientation of its record in the system of coordinates.

In case of frequent timestamps over the VCG route it is possible to estimate the speed of loops and their parts recording. The concentration of timestamps means slowing down, and depression means acceleration of the excitation spread on the myocardium.

QRS loop shape can be changed in the case of intersections, convexities or the additional pole formation. The decreasing of QRS loop total area is typical, which is especially significant in the case of left ventricle aneurysm.

Clinical case

A clinical case can be an example of VCG method of high specificity and sensitivity in a patient with acute MI.

Patient D., 59, joined the infarction department of Luhansk Clinical Multihospital № 1 2.5 hours after the beginning of intense pressing pain in chest that radiated into the left arm and could not be stopped by nitroglycerin, as well as weakness and sweating. In anamnesis — Q-negative left ventricular posterior wall MI (2003), periodical high blood pressure for five years — 160/90 mmHg. He did not receive a regular scheduled outpatient therapy. Objectively: general condition is serious. Skin is pale and dry. Over patient's lungs a clear lung sound can be heard, hard breathing, no wheeze. The left border of the relative cardiac dullness at the left mid-clavicular line. Heart sounds are muffled; the activity is rhythmic; heart rate is 66 per minute. Blood pressure is 140/80 mmHg. The abdomen is soft and painless. Liver is at the costal arch margin. No peripheral edema is detected. Patient underwent ECG and VCG-study and biochemical blood test.

Discussion

ECG shows correct sinus rhythm, 66 per minute, the electrical axis of the heart is normal (the angle is a +57°), ECG voltage is saved. In abduction V_2 QS is registered, segment ST is on the isoline, T wave is weakly positive, in V_3 there is a pathologic Q wave with ST segment depression and biphasic T wave (-+). In Inferior abduction according to Nab there is a serrated QRS complex as the equivalent of pathologic wave Q, depressed ST that becomes a biphasic T wave (-+). These changes show the acute phase of the left ventricular anterio-septal area MI. In addition, there is an

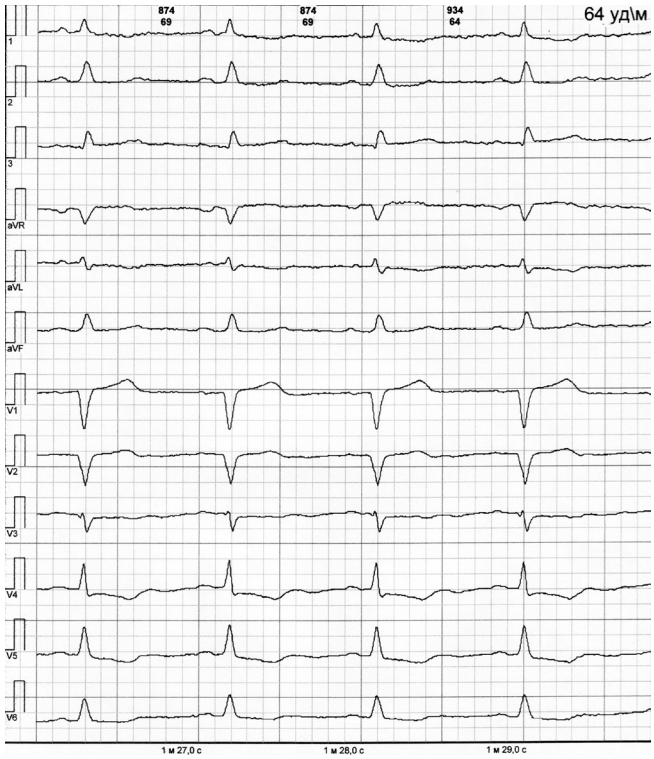

Figure 1. The electrocardiogram of the patient D.

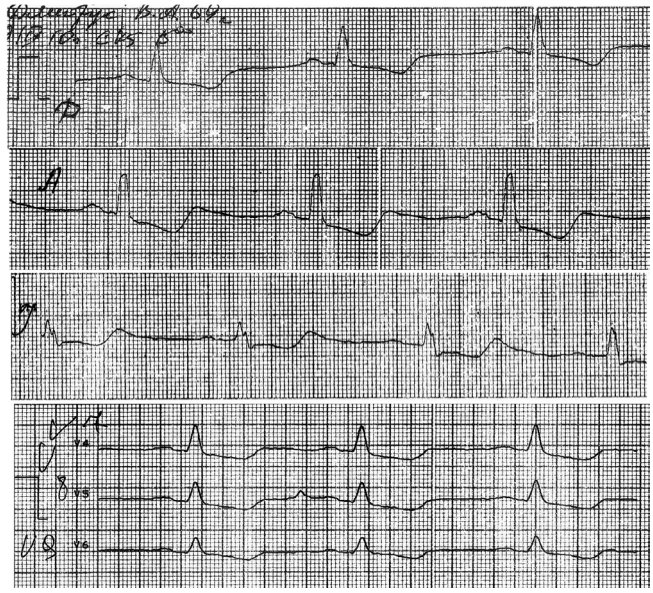

Figure 2. The accessory leads of the electrocardiogram.

obliquely downward depression of ST segment, that turns into negative T wave with relatively high R wave in abductions I, avL, V_{4-6}, and into V_{7-9}, Dorsalis and Anterior according to Nab, that is typical for hypertrophy of lateral and posterior-basal parts of the left ventricle. Along with this, the increase in P-wave duration to 0.12" may indicate a violation of intraatrial conduction (Figures 1, 2).

Myocardial necrosis is confirmed by an increase of blood protein cardiac troponin I to 4.285 ng/ml (normal 0-0.5 ng/ml) in the biochemical analysis.

VCG-study reported additional symptoms that were not detected in the ECG (Figure 3). The main vector in the system of coordinates is directed back to the left and upwards. At 1, 4 and 5 projections QRS loop rotation is not changed. In the 2nd projection the direction of the loop recording is clockwise; in the 3rd projection it is counter-clockwise, which is a deviation from norm. In BA_2 QRS loop starts in the 1st quadrant, and then goes into the 2nd quadrant. In BA_3 the signs of local intraventricular block are recorded — QRS loop is in the 4th quadrant with atypical direction of loop recording. In $BA_{2,3}$ QRS loops are in the bottom half of the system of coordinates, which means that the necrotic area includes a part of the left ventricular wall. In the 1st projection there is an indentation on the loop QRS contour. In all projections there is an intersection of QRS loop rout at the base, therefore the direction of the route of QRS and T loops is not the same.

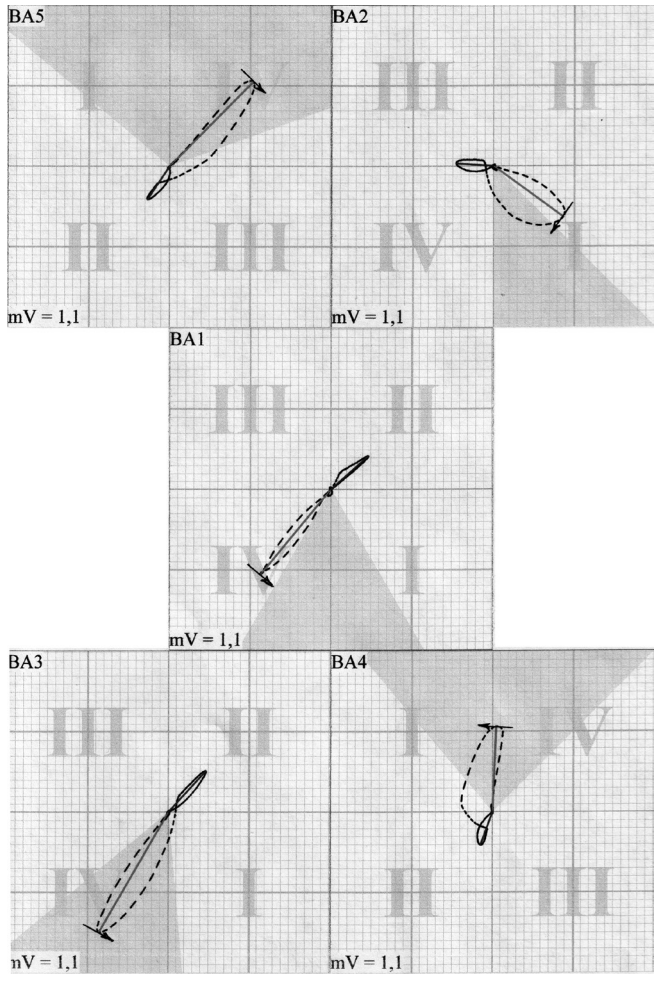

Figure 3. The vectorcardiogram of the patient D.

Table 1

Cardiogram indicators in patient D

Indicators	1st PROJECTION		2nd PROJECTION		3rd PROJECTION		4th PROJECTION		5th PROJECTION	
	Norm indicators	Indicators in patient	Norm indicators	Indicators in patient	Norm indicators	Indicators in patient	Norm indicators	Indicators in patient	Norm indicators	Indicators in patient
Maximum vector QRS, cm	1,06±0,096	1,54	0,65±0,10	1,20	0,99±0,18	1,93	1,20±0,08	1,19	1,25±0,10	1,65
Loops area QRS, mm^2	66,58±12,56	16,7	30,19±5,48	50,8	30,25±5,47	51,3	45,37±6,21	45,7	45,39±6,21	43,9
Vector angular convergence QRS-T, °	30±15	172	110±20	148	150±15	168	10±3	162	12±4	168
Maximum vector T, cm	0,64±0,09	0,66	0,37±0,09	0,49	0.48±0,13	0,72	0,63±0,09	0,47	0,55±0,08	0,52
Loops area T, mm^2	2,73 ±1,18	5,76	1,32 ±0,56	5,97	1,32±0,56	7,82	1,91±0,67	4,75	1,90±0,67	4,28
Maximum vector P, cm	0,14±0,03	0,098	0,10±0,02	0,075	0,09±0,02	0,117	0,12±0,02	0,088	0,15±0,03	0,136
Loops area P, mm^2	0,26 ±0,08	0,299	0,13 ±0,05	0,152	0,13 ±0,04	0,114	0,152±0,06	0,140	0,15 ±0,06	0,136
Vector angular convergence QRS-P, °	45±5	10	90±20	12	140±10	5	12±3	15	7±3	7

Table 2

The speed of excitation spread along loops QRS in patient D., mv/s

Projections	Loop routs	Norm indicators	Indicators in patient
1st PROJECTION	In the initial deviation vector	11,46±4,49	-
	In the final deviation vector	16,72±1,97	-
	In the initial part of the loop	40,84±3,80	40,9
	In the end part of the loop	41,49±2,79	26,34
2d PROJECTION	In the initial deviation vector	13,39±1,88	-
	In the final deviation vector	12,92±2,41	-
	In the initial part of the loop	28,92±3,24	28,71
	In the end part of the loop	24,10±2,76	26,11
3d PROJECTION	In the initial deviation vector	17,82±2,38	-
	In the final deviation vector	9,45	-
	In the initial part of the loop	41,96±5,71	43,58
	In the end part of the loop	28,39±4,13	25,83
4th PROJECTION	In the initial deviation vector	9,47±1,69	-
	In the final deviation vector	14,48±1,80	18,71
	In the initial part of the loop	40,23±3,02	29,84
	In the end part of the loop	44,59±2,30	33,65
5th PROJECTION	In the initial deviation vector	9,81±1,69	-
	In the final deviation vector	12,58±1,37	-
	In the initial part of the loop	44,70±4,03	37,29
	In the end part of the loop	44,43±2,92	30,86

The size of the maximum QRS loop vector is increased in the 1st, 2nd, 3rd and 5th projections. The area of the QRS loop is reduced 3 times in the 1st projection and increased in $BA_{2,3}$ with the unchanged total of their area (Table 1). There is timestamps concentration in the ending part of BA_1 loop over the entire loop in the 4th and 5th projections (Table 2).

In the first three projections, T loop is located at the top, and in BA_4 it is located in the lower half of the system of coordinates. T loop area is increased 1.5-1.8 times in $BA_{1,4,5}$, and more than 3 times in the 2nd and the 3rd projections with an increase in the size of its maximal vector in BA_{1-3}. QRS-T angular divergence is increased in all projections. The speed of the excitation spread over T loops is slowed in the 1st, 4th and 5th projections, and in the ending parts of loops in $BA_{2,3}$ (Tables 1 and 3). QRS and T loops are not closed in all projections: in BA_1 — 0.22 mV, in BA_2 — 0.11 mV, in BA_3 — 0.14 mV, in BA_4 — 0.25 mV, and in BA_5 — 0.21 mV. The electric forces of damage vector ST is directed upwards and to the right (Figure 4).

Thus, the backwards to the left and upward shift of the main vector in the system of coordinates, the change in QRS loops direction and location in the 2nd and 3rd projections, QRS loop contour indentations and reducing of its area in the 1st projection, intersection at the base of QRS loop in all projections; increase in QRS-T loops angular divergence; vector direction to ST necrosis forward, up and to the right; the violation of intraventricular conduction on the left ventricle front wall; the apex and the basal parts of the left and apparently, the right ventricles are the evidence of the left ventricular antero-septal myocardial-apical area acute MI.

In the loops P, analysis of the increase in their area in the 1st projection at the unchanged maximum size of the vector is noteworthy. In addition, there is timestamps concentration in $BA_{1,2}$, and in the end part of P loops in the 4th and 5th projections. These changes indicate the signs of hemodynamic overload of the atria and intraatrial conduction disturbances in the front and back walls of the atria, the postero-lateral region of the left atrium (Table 1, 4; Figure 5).

Almost 1.5 times increase in the area of QRS loop in the 2nd and 3rd projections with the broadening of loop peak in BA_2, together with the focal changes of the myocardium indicate the myocardial hypertrophy of the left ventricular posterior-lateral area.

On the second night in the hospital the patient had a paroxysm of atrial arrhythmias and the subsequent shock

Table 3

The speed of excitation spread along loops T in patient D., mv/s

Projections	Loop route	Norm indicators	Indicators in patient
1 PROJECTION	In the initial part of the loop	5,38±0,85	2,54
	In the end part of the loop	8,78±1,31	5,47
2 PROJECTION	In the initial part of the loop	3,48±0,73	2,26
	In the end part of the loop	4,99±1,14	4,06
3 PROJECTION	In the initial part of the loop	4,51±1,08	3,08
	In the end part of the loop	6,49±1,62	5,29
4 PROJECTION	In the initial part of the loop	5,29±0,78	1,54
	In the end part of the loop	8,65±1,38	3,67
5 PROJECTION	In the initial part of the loop	4,60±0,59	1,66
	In the end part of the loop	7,84±1,12	5,15

Table 4

The speed of excitation spread along loops P in patient D., mv/s

Projections	Loops route	Norm indicators	Indicators in patient
1st PROJECTION	In the initial part of the loop	3,34±0,43	2,76
	In the end part of the loop	3,52±0,52	2,52
2nd PROJECTION	In the initial part of the loop	2,61±0,33	2,13
	In the end part of the loop	2,59±0,43	1,68
3d PROJECTION	In the initial part of the loop	2,65±0,34	2,68
	In the end part of the loop	2,20±0,29	2,02
4th PROJECTION	In the initial part of the loop	2,74±0,35	2,28
	In the end part of the loop	3,26±0,51	2,35
5th PROJECTION	In the initial part of the loop	3,14±0,43	3,26
	In the end part of the loop	4,13±0,63	3,38

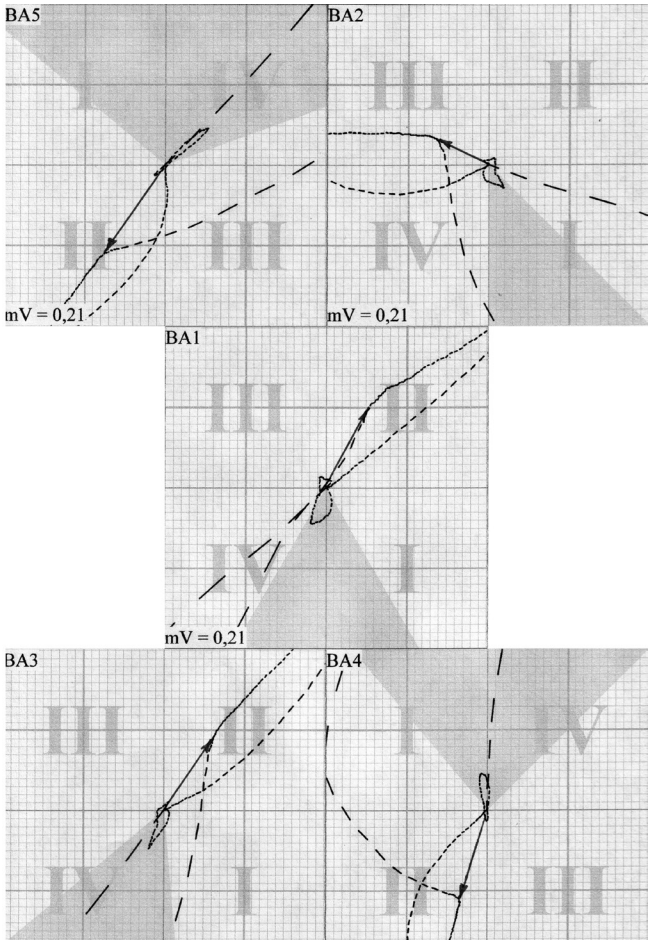

Figure 4. Damage vector ST of the vectorcardiogram is registered in all projections (for zooming in 600 times).

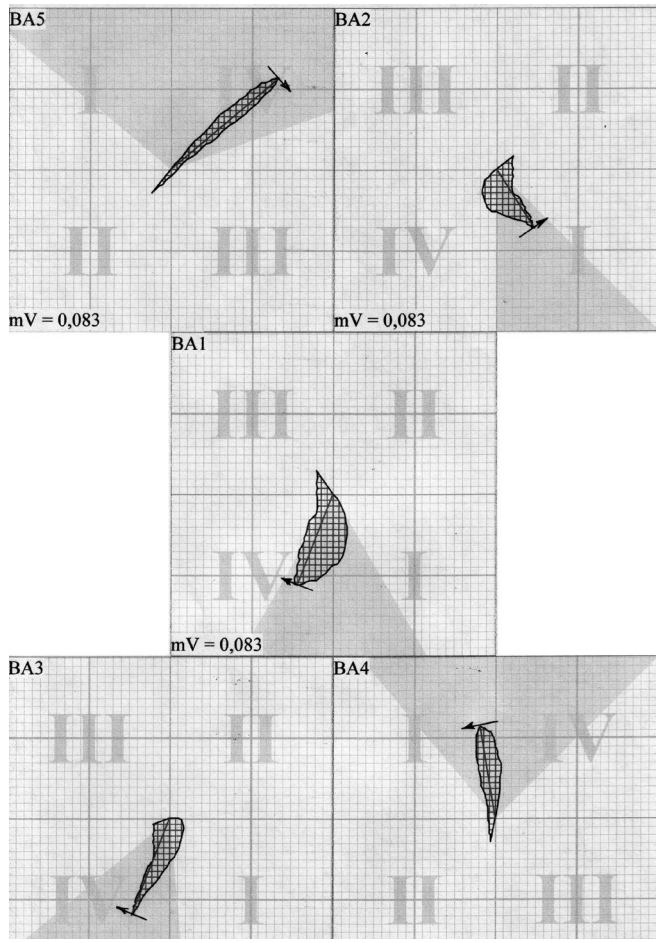

Figure 5. P loops of the vectorcardiogram for zooming in 1500 times.

and pulmonary edema. Drug therapy and electrical cardioversion were not effective. Clinical, and then biological death were pronounced on the background of asystole. The cause of death at postmortem examination is the pulmonary edema due to the left ventricular anterior-apical region acute myocardial reinfarction.

Conclusion

Additional information obtained after the complex electrophysiological examination of patients (that includes VCG and ECG), allows a real-time evaluation of the myocardium functional state with the detailed information on the degree, depth and spread of the pathological process.

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