MODERN ELECTROCARDIOGRAPHIC METHODS OF ESTIMATION OF CORONARY REPERFUSION AT THROMBOLYSIS IN ACUTE PERIOD OF MYOCARDIAL INFARCTION

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In the article the sensitivity of new vectorcardiographic research method of patients on the cardiodiagnostic complex MTM-SKM in the process of thrombolytic therapy is proved by clinical example.

Clinical case. In a patient with acute myocardial infarction of anterior wall of the left ventricle vectorcardiogram results give the opportunity to confirm a significant diminution of the area of myocardial damage with concomitant deterioration of conductivity and preserving of ischemic events due to reduction of electromotive force of the heart in the anterior wall of the left ventricle. In addition, the dynamic decrease of the electrical activity of the atria with a significant slowing of the pulse and repolarization disorder may indicate involvement of atriums in the pathological process with a considerable blood flow disorder in them.

Conclusion. This method allows to make a quality and quantitative evaluation of the efficiency of the reperfusion therapy, as well as to obtain the information about the electromotive force of the heart both in the necrobiosis zone and out of myocardium affection zone.

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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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СОВРЕМЕННЫЕ ЭЛЕКТРОКАРДИОГРАФИЧЕСКИЕ МЕТОДЫ ОЦЕНКИ КОРОНАРНОЙ РЕПЕРФУЗИИ ПРИ ТРОМБОЛИЗИСЕ В ОСТРОМ ПЕРИОДЕ ИНФАРКТА МИОКАРДА

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В статье доказана чувствительность нового векторкардиографического метода исследования пациентов на кардиодиагностическом комплексе МТМ–СКМ в процессе проведения тромболитической терапии на клиническом примере.

Клинический случай. У пациентов с острым инфарктом миокарда передней стенки левого желудочка результаты векторкардиограммы дают возможность подтвердить значительное сокращение площади повреждения миокарда с одновременным ухудшением проводимости и сохранения ишемических событий из-за снижения электродвижущей сила сердца в передней стенке левого желудочка. Кроме того, динамичное снижение электрической активности предсердия с существенным замедлением пульса и расстройством реполяризации может означать участие предсердий в патологическом процессе со значительным расстройством кровяного потока в них.

Вывод. Этот метод позволяет дать качественную и количественную оценки эффективности реперфузионной терапии, а также получить информацию об электродвижущей силы в сердце, как в зоне некробиоза, так и в зоне повреждения миокарда.

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

According to Euro Heart Survey I, in the last decade, the 30-day mortality in acute ST elevation myocardial infarction (STEMI) in Europe has decreased from 8,4% to 6,4% [1]. This happened owing to the introduction into clinical practice of methods of recanalization of the culprit coronary artery, which was the key to restoring of blood flow to the heart and preventing necrosis, or at least significantly reducing the damage of the heart muscle. According to the guidelines of the European Society of Cardiology (2008), with a confirmed diagnosis of STEMI, there are two real ways to restore patency of the culprit coronary artery — it is thrombolytic therapy and/or primary percutaneous coronary intervention (PCI) [2].

Primary PCI has an advantage over thrombolytic therapy, initiated in hospital. Invasive approach contributes to further reduce of the death risk by 30%, non-fatal recurrent MI — by 58%. In addition, there is a lower rate of intracranial bleeding. Currently, PCI is preferred if implemented no later than 90 minutes after the onset of myocardial infarction, prior to contact with the medical staff [3]. This advantage is also evident in terms of operations with highly qualified personnel in appropriate conditions [4]. In Europe and in the United States the number of invasive procedures in STEMI has increased: coronary angiography — 52–63%, PCI — 25–37%, aortocoronary bypass — 12% [1].

Dr. Goldstein Patrick from Lille University Hospital, France, stressed that saving of patient with MI is a race against time. However, access to timely and optimal primary PCI is limited worldwide. Thus, about 20–30% of those with STEMI in Europe still do not receive reperfusion therapy in any form, and for many of those with reperfusion it goes beyond the recommended “therapeutic window” [5]. Even in the United States, only 20% of the population lives in areas where there is a possibility of PCI [6]. At the same time, fibrinolytic therapy is universally available and can be scheduled in a timely manner by general practitioners and emergency care to patients in the first hours of STEMI

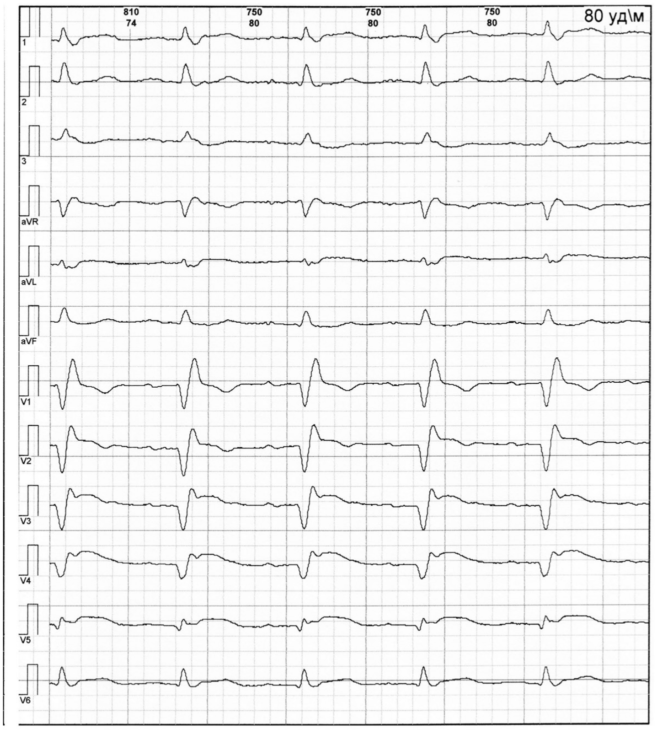

Figure 1. Electrocardiogram of patient R. before thrombolysis

[7]. Obviously, if invasive treatment is impossible or is conducted with a significant delay in time and cannot be executed under appropriate conditions, it is necessary to give fibrinolytics and subsequently, if necessary, to consider the possibility of revascularization [8]. In the first 2–3 hours of ischemia MI mortality in the thrombolytic therapy and PCI is comparable [4].

The main aim of the culprit coronary artery opening is not the restoration of its patency, but firstly the resumption of blood flow at the tissue level, which is achieved with thrombolytic therapy in 30–40% of cases [9]. In clinics with modern equipment it is possible to estimate myocardial reperfusion using coronary angiography (index MBG), myocardial scintigraphy with 99mTc, Doppler echocardiography and magnetic resonance imaging with contrast, positron emission tomography, and electrocardiography (ECG) [4, 10] which is used in the practice of infarct compartments as the most accessible method. However, in some cases, to control the dynamics of thrombolytic therapy, ECG failed to disclose all aspects of change in the electromotive force of the heart (EMF/H). Its vector analysis is a promising area in detecting myocardial electrical instability. In recent years, in case of acute coronary pathology researchers use adjusted orthogonal systems of leads, including those according to Frank and Mac Fi-Parunhao, not only in Ukraine [11] and Russia [12], but also in many countries of European Union (Sweden [13], Bulgaria [14]), as well as in the United States [15] Canada [16] Singapore [17]. I. T. Akulinichev methodic does not have the faults of vector analysis of ECG due to the location of electrodes near the heart instead of geometric shapes building. VCG projections reflect the potential of certain areas of myocardium, which is especially important in case of its focal damage: first projection reflects the electrical activity of the anterior region of the heart, the second — the posterior-lateral areas of left ventricle (LV), third — right lower diaphragmatic area, the fourth — of the apex, and the fifth — base of the heart. M. B. Tartakovskij made some changes to the I. T. Akulinichev precardiac system by placing the electrode from the back to V_7 ECG position, with the recording of three chest leads according to Neb [18]. Five leads system by I. T. Akulinichev leads in Tartakovskij modification gives an advantage in examining of critically ill patients with acute cardiovascular disorders due to better electrodes location. Comparing the results of ECG and VCG allows to expand diagnostic capabilities of both methods. In the 50–70s of the last century in the USSR the study of VCG features in MI on the VEKS-O1 device (constructed by Akulinichev I. T.) was conducted, which was very difficult because of the lack of automated material handling, multi-stage analysis, a large scatter of results, lack of time characteristics. Diagnostic errors were the result of low resolution of the device, which made the analysis of loops track, and differential diagnosis of convergence and loops intersection harder, and almost insufficient information content in the isoelectric point. Since 2003 Sieverodonetsk Scientific and Production Enterprise "Microterm" together with the Lugansk State Medical University and Volodimir Dal East-Ukrainian National University have developed a new advanced polygraph MTM-SCM [19]. This device makes it possible to obtain, with high resolution (up to 3000 times) additional indicators of electrical activity of the heart, that were not previously possible to research; real-time analysis of received topographic information and automatic processing of the results, including in the process of reperfusion therapy control [20].

The new method has been worked out and tried on 181 patients with acute MI, icluding14 patients with STEMI in thrombolysis. A clinical case may be an example of the use of highly sensitive polycardiography in the dynamics of thrombolytic therapy evaluation.

Purpose of the research — to evaluate the electrical activity of the myocardium in acute MI with thrombolytic therapy using a modification of electro-vectorcardiography.

Clinical case

Patient R. was taken to the infarction department of Luhansk City Clinical Multihospital № 1 with complaints of precordial discomfort in 2 hours after the beginning of growing pressing pain in chest, that were stopped by ambulance crew before the patient was brought to hospital. Blood pressure — 160/90 mm Hg.

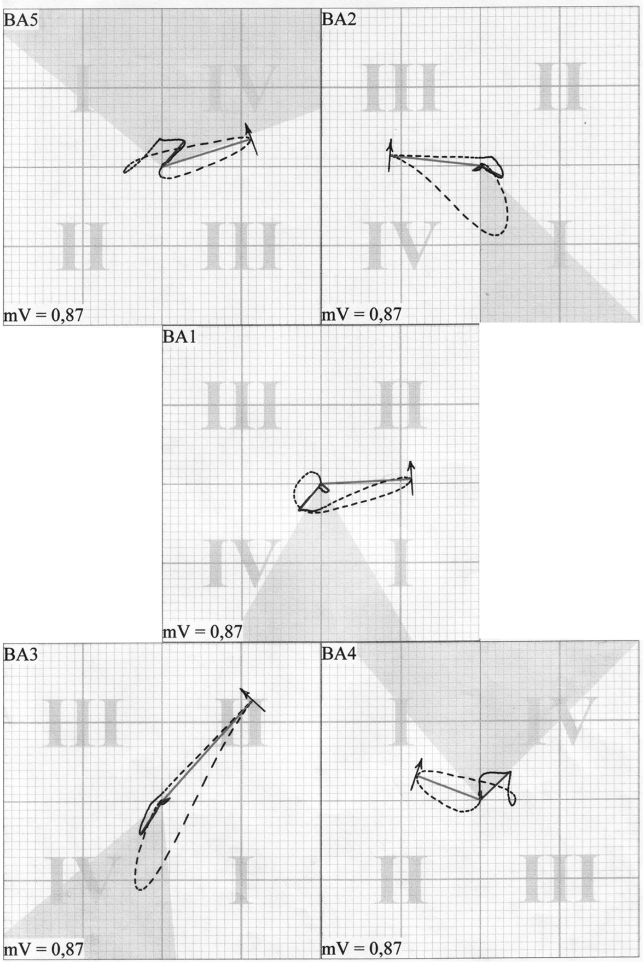

Figure 2. Vectorcardiogram of patient R. before thrombolysis

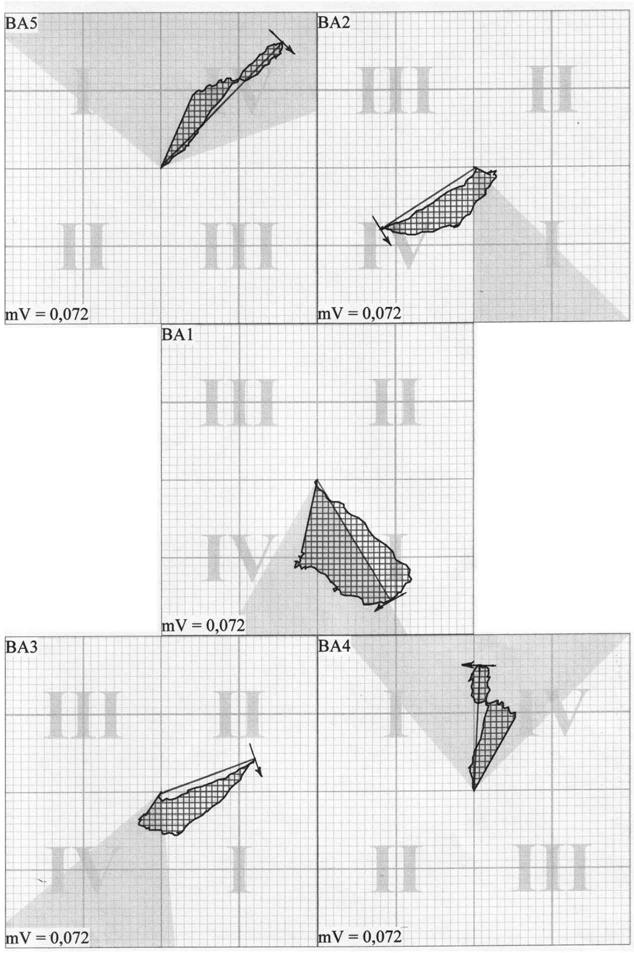

Figure 3. P loops of vectorcardiogram, enlarged up to 2000 times, before thrombolysis

Discussion

The ECG on admission showed right sinus rhythm, 78 per minute, the voltage is reduced to the chest leads, electrical axis of the heart is normal (a +67° angle). QR in $V_{2-}5$ are registered with ST-segment elevation in $V_{2-}6$ and I, avL with a dominant in V_4 to 0.4 mV with total right bundle branch block as a reflection of damage and necrosis of anteroseptal-apical-lateral region of the LV and the reciprocal changes in III, avF as segment ST depression (Figure 1). Taking into account the time of admission from the beginning of anginal attack, the ECG data, and the lack of absolute and relative contraindications, the patient was assigned 1.5 million units of streptokinase intravenously on a background of basic therapy according to the protocol of care for patients with MI with Q wave.

With the help of vector analysis additional information about the EMF/H was provided (Figure 2). QRS loop is shifted to the left and up a little forward, because electrical forces, directed forward, are decreased [21]. In the first projection QRS loop has a sharp shift upwards and to the left, the initial part is increased and directed upwards and to the right. Local symptoms of intraventricular blockade are seen in the initial location of the QRS loop in the III quadrant in first projection and in the IV quadrant in the third projection, and loops are crossed in $BA_{4,5}$. At the same time QRS loop in BA_1, with a start in the upper half of the coordinate system moves to the bottom; in в BA_2 the main part of QRS loop is located in quadrants I and IV; in BA_3 the initial part of the loop is in the lower half of the coordinate system, which is typical for nontransmural spread MI [18]. In the second and third projections QRS loops are asymmetrical, apexes are pointed, in the initial part there is an additional pole [21], they change their direction: the projection of the second loop moves clockwise, and the third projection — counterclockwise. Phase relations disorder manifests itself a peculiar direction of QRS loop in BA_2: it begins in the I quadrant, and the main part is located on the left (in space — behind) from the isoelectric center [22], which confirms the anterior localization of MI. At the same time, the location of most of the QRS loop in the IV quadrant in BA_2 indicates that the side wall of the left ventricle is involved in the pathological process. QRS loops orientation changes in the in projection IV shows apex damage: initial part of the

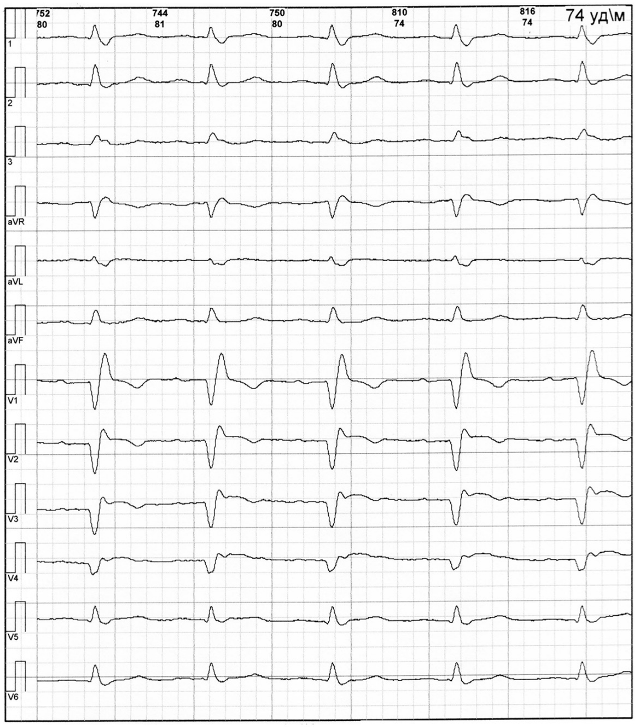

Figure 4. Electrocardiogram of patient R. 90 minutes after thrombolysis

loop is located in the lower half of the coordinate system [18].

The formation of additional pole with a cross in the final part of the QRS loop in projections 4 and 5, that is recorded with a slow movement of the recording beam and is directed upwards and to the right, recording of the initial part of QRS loop with fast movement of the beam in projections 2, 3 and 4 confirm the presence of a complete right bundle branch block, and indicates that the zone of ischemia and/or necrosis is spread to the heart septum [21].

Reduction of the total area of QRS loops happened due to 2–2,5 times decrease in the area of 1, 4 and 5, without significant changes in projections of maximum vector. Timestamps thickening is observed throughout QRS loop in BA$_{1,4,5}$, and also in the final deviation vector in IV and V projections. T loops are directed to the right and down, they are rounded and situated outside the QRS loops of all projections, their maximum vector is reduced in 1, 4 and 5 projections. In these projections, there is thickening of the time stamp of the loop T. The area of T loops is increased in all projections with maximal changes in BA$_{4,5}$. Recording of broadened T loops and QRS loops in projections 1, 4 and 5 is in the opposite direction. The angular divergence of loops QRS and T is increased in BA$_{1-5}$ (Table 1–3). Loops QRS and T are not closed: in BA$_1$ to — 0.32 mV, in BA$_{2,3-}$ 0.08 mV, in BA$_4$–0.46 mV and in BA$_5$–0.33 mV. The vector ST is directed forward, to the left and downwards as the equivalent of damaged anterior septum-apical-lateral wall of the LV.

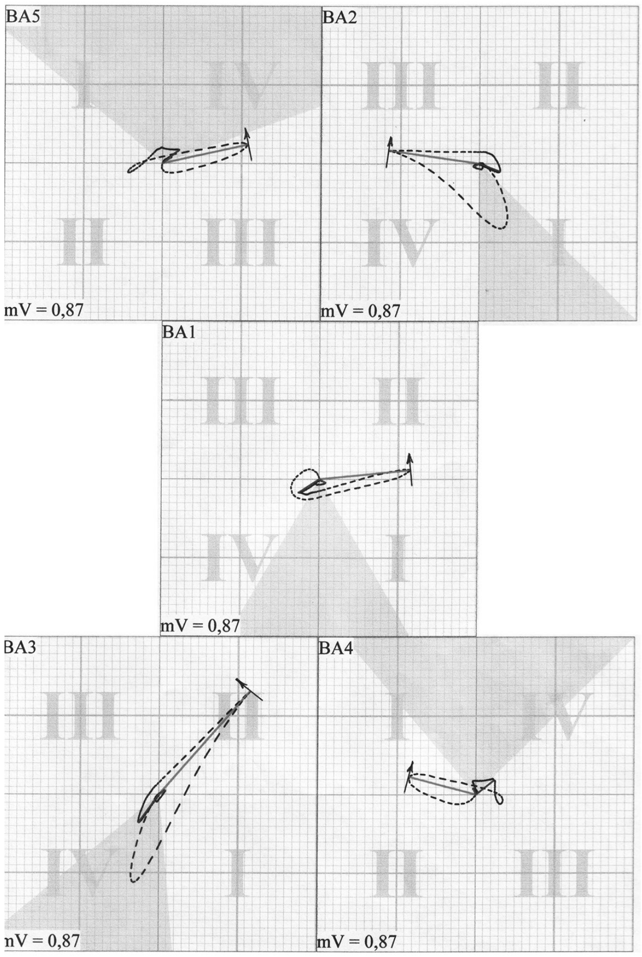

Figure 5. Vectorcardiogram of patient R. 90 minutes after thrombolysis

Thus, in addition to the ECG information about damage and necrosis of the anterior septum-apical-lateral wall of the left ventricle, vectorcardiography allowed to obtain data about the disorder of myocardial blood supply in the basal parts of the ventricles, which is confirmed by a disorder of the interrelation of QRS and T loops and qualitative changes of the loop T in projection 5, and about pulse slowing in the anterior wall of the left ventricular apex and basal parts of the ventricles due to the change in speed markers in BA$_{1,4,5}$. In addition, the increase in the of P loops area in the first three projections at 1,3–1,8 times at unchanged indicators of their maximum vectors show hemodynamic overload of the atria (Figure 3). Cove-like P loops route, their cross at the base of BA$_{4,5}$ with a change in the loops rotation direction, thickening of the time markers on the P loops in all projections indicate excitation spread slowing of the atrial myocardium, concentrated mainly in the posterior-lateral wall of the left atrium and posterior wall of the right atrium. The increase in the angular divergence of the loops in the QRS-P in projections1, 4 and 5 shows repolarization disorder in front of the atrial posterior-lateral wall of the left atrium and posterior wall of the right atrium (Table 1, 4).

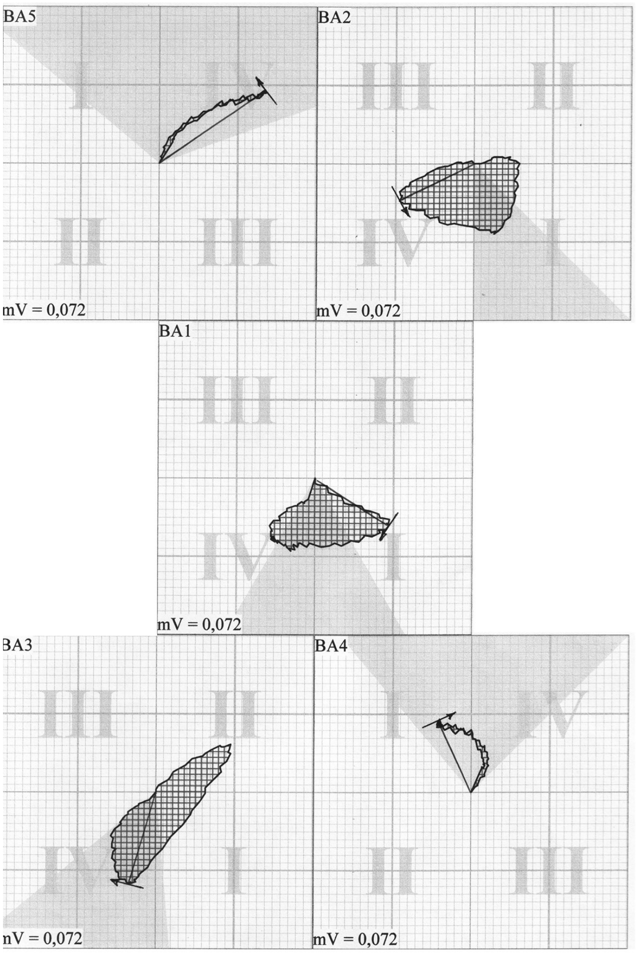

Figure 6. P loops of vectorcardiogram, enlarged up to 2000 times, 90 minutes after thrombolysis

90 minutes after thrombolysis ST-segment depression by 50% or more from baseline in the V_{2-4} and reperfusion arrhythmias are not registered on the ECG, but in $V_{5,6}$ ST segment is decreased to contour and R wave amplitude is increased (Figure 4). VCG-study showed a slight decrease in the dynamics of QRS area in all projections, decrease of the total area of T loops in projections 1, 4 and 5, the increase in the angular divergence of QRS and T loops in $BA_{1-4,}$ decrease in the disjunction of QRS and T loops in projection 1 to 0.13 mV, in projection 4 — to 0.25 mV and in projection 5- to 0.15 mV (Figure 5). At the same time, R loops area was increased in projections 2 and 3 together with decrease in the angular divergence of QRS and P loops and multidirectional changes of speed markers in all projections. However, in the $BA_{4,5}$ significant decrease in P loops area was followed by two loops crosses (Figure 6). So, as a result of vector analysis together with decrease in the electrical activity of the LV myocardium reduction of damage zone is registered (1,8–2,5 times decrease of the QRS and T loops opening) in the anterior septum-apex-side area with persistent left ventricular ischemia around damage zone. In addition, the decrease in the EMF/H in the posterior atrial wall is registered, together with a local blockade (P loops cross in $BA_{4,5}$) with hemodynamic overload of the atria against the functional heterogeneity of the myocardium due to ischemic manifestations (Table 1, 4).

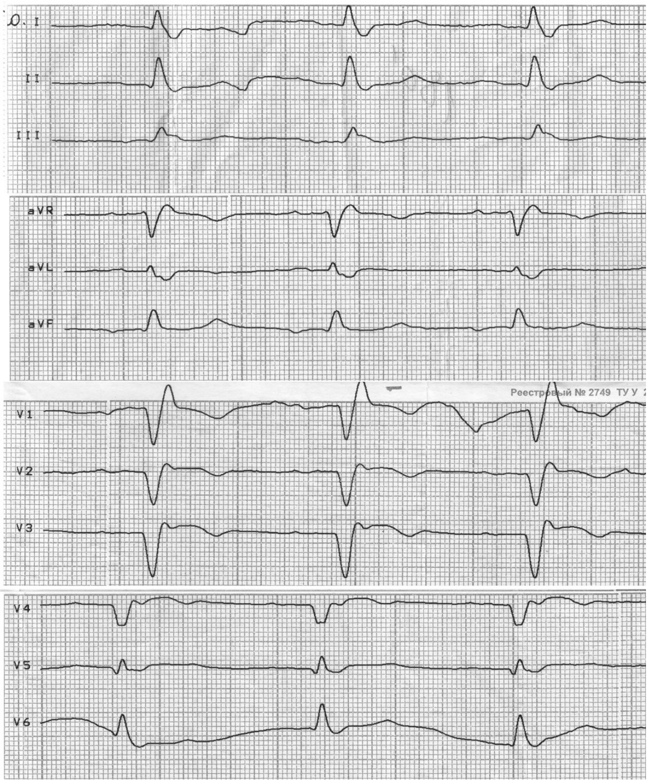

Figure 7. Electrocardiogram of patient R. 180 minutes after thrombolysis

180 minutes after the start of thrombolytic therapy ECG showed signs of effective reperfusion therapy in the form of ST-segment decrease in V_2 by 0,10 mV, in V_3–0,15 mV, in V_4–0,25 mV, which corresponds to a reduction in ST-segment to 50% or more from the initial number. Reperfusion arrhythmias are not registered (Figure 7).

VCG shows QRS loop cross in projection 1 together with the reduction of its area, T loops cross in projections 1, 4 and 5, and decrease of T loops area in all projections (in $BA_{2,3}$ parameter was normalized), thickening of the time markers in T loops in projections 2 and 3, some increase in the angular divergence of QRS and T loops in projection 1, 1,3–1,8 times more decrease of QRS and T loops opening value: in BA_1 to 0.07 mV, in BA_2 — to 0.06 mV, in BA_3 — to0.05 mV, in BA_4 — to 0,16 mV, and in BA_5 — to 0,11 mV (Figure 8). In all projections the cross of P loops can be seen, with the change of their rotation direction, a progressive decrease in their area, multidirectional changes of the angular divergence of P and QRS loops, and time markers thickening in the dynamics of the loop P in BA_{1-5} (Figure 9, Table 1, 3, 4). Thus, VCG results allow to confirm a significant reduction in the

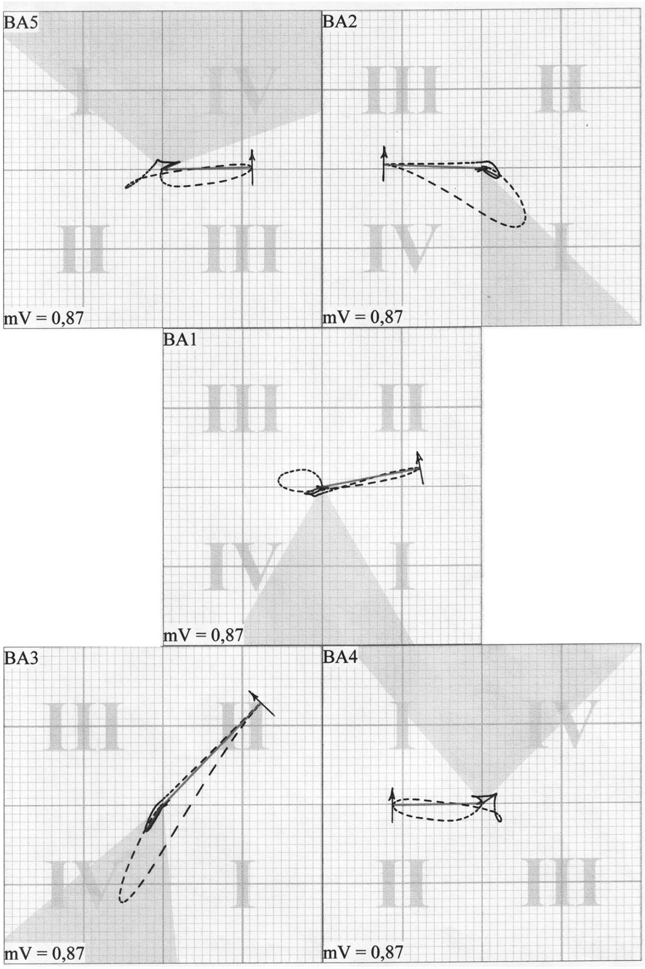

Figure 8. Vectorcardiogram of patient R. 180 minutes after thrombolysis

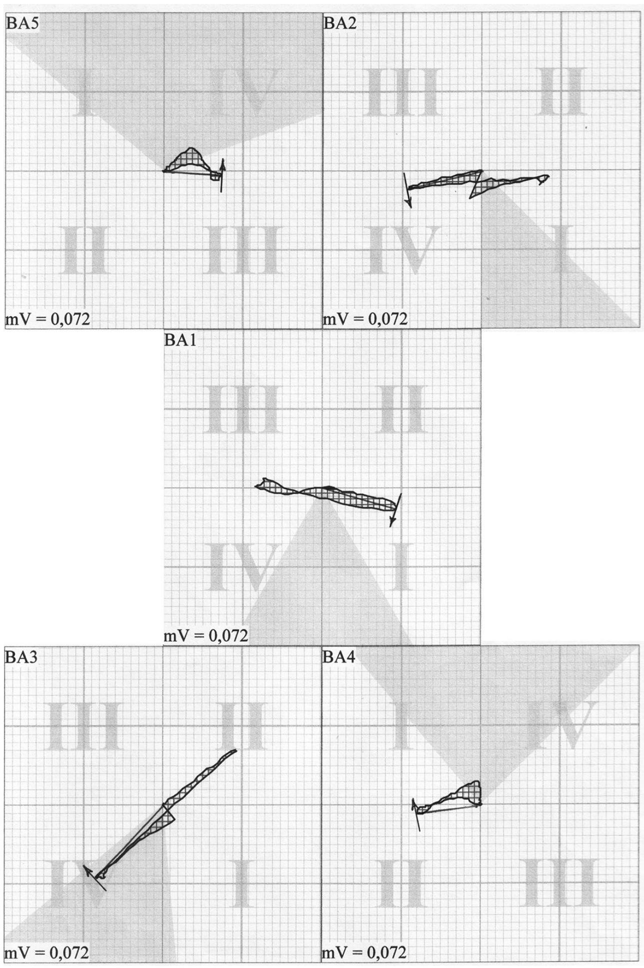

Figure 9. P loops of vectorcardiogram, enlarged up to 2000 times, 180 minutes after thrombolysis

myocardial injury zone with a concomitant deterioration of conductivity on the front wall of the left ventricle and the resumption of ischemic events together with EMF/H decrease. Dynamic reduction in the electrical activity of the atria with a pulse slowing and the repolarization disorder may indicate that the atria are involved into pathological process with a major blood supply disorder in them.

Conclusion

Modern VCG method of EMF/H study on the new MTM-SCM polygraph allows not only to evaluate the effectiveness of thrombolytic therapy in high-resolution, in real-time, and in dynamics, but also to obtain information about the electrical activity in the affected area of the myocardium, and outside necrobiotic changes of the heart muscle.

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