EFFICACY OF CARDIOSYNCHRONIZED ELECTRICAL STIMULATION IN PATIENTS WITH ACUTE HEART FAILURE

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Objective: to study the efficacy of external cardiosynchronized muscular counterpulsation (CMC) in patients with different variants of acute heart failure. The study included the examination results of 62 patients with acute heart failure, which undergo two variants (two groups) of therapy: 1) only the standard drug therapy (diuretics, nitrates, *etc*.) and 2) in the case of its inefficacy over 12 hours, combination of the drug therapy with the CMC sessions over 7 days. The clinical assessment of the patients under examination characterized the group with the standard therapy as less severe. In 64% of the group 2 patients, a significant improvement in the form of improvement in the fluid balance indices was noted during the combined therapy.

Key words: external cardiosynchronized muscular counterpulsation, acute heart failure, ECG-dispersion mapping, predictors of death.

Rational strategies for the treatment of patients with acute heart failure (HF) are currently some of the most complex problems of clinical practice. Quite widespread problems in such patients are the resistance toward diuretic therapy and impossibility of surgical interventions for various reasons.

The treatment of chronic heart failure (CHF) evolved from the symptom management using diuretics and digoxin to the nosoptropic therapy using ACE inhibitors, beta-blockers, spironolactone, *etc*. Pharmacological methods of treatment of HF are undoubtedly of great importance, but there are a number of patients whose treatment requires application of different methods, including the assisted circulation methods using mechanical and biomechanical systems, which promote the fluid shift in order to decrease the heart work or to increase its energy delivery (through improvement of coronary and systemic perfusion) [1—5].

The development of new technologies resulted in active introduction of various approaches for such patients using growth factors and cell technologies under the common name “alternative revascularization methods”. To date, there are numerous investigations confirming a decrease in the clinical implications of the disease, improvement in the effort tolerance in patients with refractory angina and there are data indicating a decrease in the signs of myocardial ischemia when using this type of therapy. In this regard, of special interest are external cardiosynchronized muscular counterpulsation (CMC) and enhanced pneumatic-mechanical external counterpulsation (EPMEC) [6, 7].

The EPMEC method is a next step in the development of external counterpulsation techniques, which combines beneficial effects of counterpulsation and electrical stimulation. It is based on the wavelike inflation of three pairs of cuffs being put on patient’s legs. For this purpose, in modern systems the cuffs are put on the patient legs and air is blown therein during diastole at a high ever increasing rate from the calf muscle to the lower femoral part and then to its upper part and glutes at the subatmospheric pressure synchronously with the cardiac rhythm. This leads to the arterial backflow and the decrease in the diastolic pressure in aorta, which, in turn, leads to the increase in the coronary perfusion pressure and enhancement in the myocardial perfusion. Also, there occurs an increase in the venous return to the right heart. Inflation of cuffs occurs synchronously with ECG of patient during diastole and begins from the calf muscle cuffs, the femoral cuffs are blown up, and then the gluteal cuffs are blown up. Thereby, the EPMEC system favors the venous blood flow in the period of diastole.

In contrast to the invasive prototype (intraaortic balloon pump, IABP) and EPMEC, the CMC method allows causing short-term muscular contractions strictly at the time of diastole. A direct comparison of IABP with EPMEC and CMC showed that both methods of assisted circulation have similar circulatory effects (an increase in the ejection and a decrease in the left ventricular work). The advantage of CMC consists not only in non-invasiveness, but also in the capability to enhance the peripheral blood flow. As such, this is a unique hybrid of assisted circulation and electrical stimulation, which possesses useful therapeutic properties of both methods of body exposure [7, 8]. The mechanism of action consists in the training effect created due to the decrease in the peripheral vascular resistance and response of the heart rate to exercising. At the present time, there are single, but reassuring reports on the application of muscular counterpulsation. In Russia, the first clinical study of the efficacy and safety of muscular counterpulsation upon treatment of CHD patients was performed in the A.N. Bakulev Scientific Center for Cardiovascular Surgery, A.L. Myasnikov Institute of Clinical Cardiology of the Russian Cardiologic Research and Production Complex, and Tomsk Cardiologic Scientific Center [9—12].

To date, there are studies evidencing the efficacy and safety of CMC in the combined treatment of patients suffered from CHD and stable angina refractory to the drug therapy in the case where myocardial revascularization methods cannot be used [13, 14].

Preoperative application of CMC favors stabilization of hemodynamics and calmer anesthesia of ischemic patients, as well as has a positive effect on the early course of the disease after coronary arterial bypass graft [15].

Introduction of CMC to the complex therapy in CHF patients leads to a significant increase in the left ventricular contractibility, has a positive effect on the central hemodynamics, increases the exercise tolerance, and improves patient's life quality. However, in the available literature sources there is a few information concerning the effect of external counterpulsation on the course of different forms of acute heart failure (AHF). Thus, it is obvious from the above that the therapeutic efficacy of CSEMS in CHD and heart failure patients should be studied further.

The aim of the present work was to study the efficacy of external cardiosynchronized muscular counterpulsation in patients with different variants of acute heart failure.

Materials and research methods. The present study included 62 patients with AHF (the average age was 71 ± 11 years), which were admitted to the coronary care unit by the ambulance team with diagnosis of "fluid lungs". The pulmonary edema developed during either acute coronary pathology (de novo) or acute decompensation of chronic heart failure (CHF). All AHF patients were divided into two groups: the first group received only the standard drug therapy and the second group received the standard therapy in combination with CMC. CMC was started after more than 12 hours from the time of clinical implications if the standard therapy was inefficient. The main causative factor of AHF in the patients under study was CHD, in particular myocardial infarction.

The general characterization of AHF patient group is given in Table 1. The first group included 23 patients with AHF (13 males and 10 females) at the age from 52 to 90 years (the average age was 72 ± 11 years) and the second group included 39 patients with AHF (14 males and 25 females) at the age from 39 to 85 years (the average age was 70 ± 10 years). The most frequent co-morbidities were diabetes mellitus (DM), chronic kidney disease (CKD), anemia, and hypostatic pneumonia. DM and hypostatic pneumonia occurred 1.5-fold oftener and CKD occurred 3-fold oftener in the second group.

Besides the anamnestic data collection and physical examination, the diagnostic maneuver included: biochemical blood counts, electrocardiography (ECG) in 12 indirect leads, ECG-dispersion mapping, echocardiography (EchoCG) at rest, and multifrequency segmental bioimpedance analysis. To analyze the balance of body water sectors and to asses the phase angle reflecting the condition of cell membrane, an ABC-01 Medass instrument was used. We analyzed the dynamics of such indices, as body fluids (BF), extracellular fluid (ECF), intracellular fluid (ICF), and phase angle (PA).

ECG-dispersion mapping was performed using a Cardiovisor-06M microalternation display. The dynamics of the myocardial microalternation index (MMI) reflecting myocardial electrophysiological properties and metabolic disturbance was evaluated. The MMI values were continuously monitored for 15 min (the time of each measurement was 30 sec).

According to the available recommendations, the contraindication to enhanced external counterpulsation were: severe pathology of the valvular apparatus; uncontrolled arterial hypertension (> 180/110 mm Hg); malignant arrhythmia (incorrect and tachy form of atrial flutter fibrillation, frequent ventricular arrhythmia, ventricular tachycardia), HR > 135 or < 35 beats per min; the presence of implantable cardiostimulator or cardioverter-defibrillator; severe pathology of peripheral vessels; cardiac catheterization less than 2 weeks ago due to the probability of hemorrhage from the puncture site of femoral artery; thrombophlebitis (phlebemphraxis), severe variceal disease, trophic ulcers; hemorrhagic diathesis, therapy with indirect anticoagulants having a prothrombin time of 15 sec, INR more than 2.0; high pulmonary hypertension; aneurysm of thoracic and/or abdominal aorta.

Examination of AHF patients was performed in two steps. I step: first day of stay in the in-patient department just before the first session of CMC (in the case of combined therapy); II step: 7 days of stay in the in-patient department, after the seventh session of CMC. The end point of the investigation was the AHF patient fatality within the first month of observation and the first year.

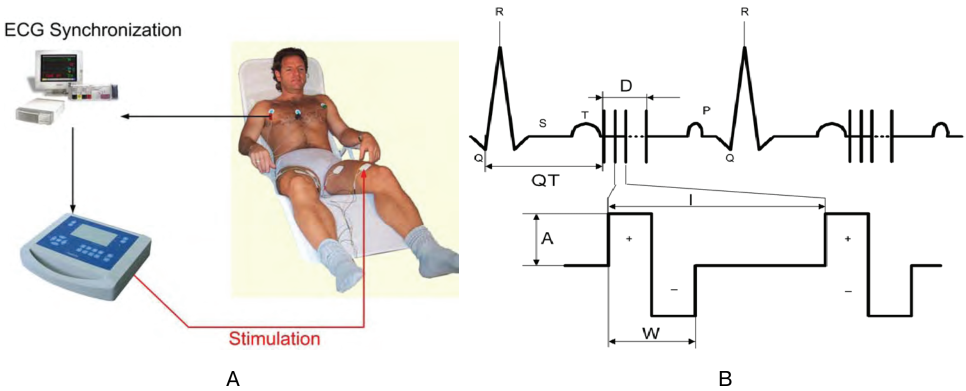

Fig. 1. A) External view of the cardiosynchronized muscular counterpulsation device and B) its principle of operation (D is a duration, QT is a delay, A is an amplitude, I is an interval, W is a pulse width). The diagram reflects the chain (or beam) of impulses started precisely at the T-wave end of the QRS complex, which is revealed during tuning of the device. The fixed pulse width is 1 m/sec. The delay time shown in the diagram is automatically calculated by the device microprocessor unit (Bazett), B) External view of the noninvasive enhanced external counterpulsation system

During CMC, a third generation apparatus (CardioLa LTD, Winterthur, Switzerland) was used. The counterpulsation mode was achieved by generation of myostimulating impulses synchronized with the R-wave on ECG after the T-wave. A heart rate transmitter is dedicated for the synchronization of stimulation with the heart rate. Independent ECG was applied to verify the coincidence of stimulation time with the QRS complex. The delay time equal to the QT interval was set individually under the ECG control. The beginning of the stimulation pulse chain coincided exactly with the T-wave end. The CMC sessions were performed daily over 7 days. The duration of each interval was 60 min. No complications from the side of cardiovascular system were observed during external counterpulsation in AHF patients, but this category of patients demonstrated low compliance toward the therapy performed.

Statistical processing of the results was performed on a personal computer using the Microsoft Excel 2007 and STATISTICA (v 6.0) statistical program packages. The results of the study are represented as arithmetic mean values ± standard deviations (M ± δ). To assess the significance of difference between these two studies in different patient groups, Student's t-test with and without Watt coefficient was used. The difference were considered as significant at $p < 0.05$. The Pearson and Fischer criteria were used upon assessment of the difference significance between qualitative indices.

Results and Discussion. The clinical assessment of the patients under examination characterized the group with the standard therapy as less severe and, in the group with the combined therapy, the signs of chronic kidney disease were noted in 64% of cases and the signs of disturbance in the carbohydrate metabolism were noted in 74% of cases (Table 1).

Table 1

General characteristic of the AHF patients groups included to the study (*n* = 62)

Index		**Group 1 (*n* = 23)** Standard therapy	**Group 2 (*n* = 39)** Combined therapy
Average age (лет)		72 ± 11	70 ± 10
M: F		13:10	14:25
Age, years	60	3 (13%)	6 (15%)
	> 60	20 (87%)	33 (85%)
CKD		**5 (22%)**	**25(64%)**
Diabetes mellitus		**11 (48%)**	**29 (74%)**
Anemia		**7 (30%)**	**13 (33%)**
Hypostatic Pneumonia		**10 (43%)**	**24(62%)**
Ejection fraction, %	> 40	14 (61%)	23 (59%)
	30—40	5 (22%)	11 (28%)
	< 30	4 (17%)	5 (13%)

The dynamics of biochemical blood indices at the steps of the study in both groups is shown in Table 2. When analyzing the levels of urea and creatinine at the first step of the study in the group with the combined therapy, a more severe course of CKD ($p < 0.05$) was found, which characterizes this group as more severe according to the course of chronic kidney disease.

Table 2

Dynamics of biochemical indices in the AHF patients groups at the examination steps

Indices	Groups under study	Examination step	
		I	II
Urea, mmol/L	Group 1 (n = 23)	7.2 ± 4.5	8,1 ± 4,6
	Group 2 (n = 39)	11.7 ± 7.3^	8,2 ± 4,5*
	N = 2.6—8.3		
Creatinine, mmol/L	Group 1 (n = 23)	0.12 ± 0.04	0,13 ± 0,05
	Group 2 (n = 39)	0.16 ± 0.04^	0,13 ± 0,08*
	N = 0.05—0.12		
Glucose, mmol/L	Group 1 (n = 23)	8.6 ± 2.1	6,8 ± 2,7*
	Group 2 (n = 39)	10.2 ± 3.7	6,9 ± 2,8*
	N = 3.9—6.4		
Hb, g/L	Group 1 (n = 23)	124.1 ± 34.8	116,5 ± 28,9
	Group 2 (n = 39)	125.6 ± 28.7	122,7 ± 21,6
	N = 120—160		

Notes: * — the differences between two steps in the groups under study are significant, ^ — the differences between two group at the examination step, $p < 0.05$.

According to the EchoCG data, the ejection fraction (EF) < 30% was found in 4 patients (17%) in the group with the standard therapy and in 5 patients (13%) in the group with the combined therapy; the EF from 30 to 40% was noted in 5 patients (22%) in the first group and in 11 patients (28%) in the second group; and the ejection fraction > 40% was found in 14 patients (61%) in the group with the standard therapy and in 23 patients (59%) in the group with the combined therapy.

All AHF patients in the groups under study were divided into two subgroups in view of positive (a) and negative (b) dynamics of the mean fluid balance indices: BF, ECF, ICF, and PA (Table 3).

Table 3

Dynamics of the balance of water body sectors in the AHF patient groups under study at the examination steps

Indices	Groups under study	Subgroups	Examination step I	Examination step II
BF, L	Group 1 (n = 23)	1a (+, n = 12)	40.8 ± 5.2^	34.3 ± 6.2*
		1b (–, n = 11)	35.4 ± 8.9	36.5 ± 9.0^
	Group 2 (n = 39)	2a (+, n = 25)	41.2 ± 9.0^	33.2 ± 8.9*
		2b (–, n = 14)	32.9 ± 8.8	37.7 ± 12.0^
	BF, L due value (n = 62) 30.5 ± 8.3			
ECF, L	Group 1 (n = 23)	1a (+, n = 12)	21.0 ± 4.5^	17.6 ± 2.9*
		1b (– n = 11)	18.6 ± 4.6	18.9 ± 5.0
	Group 2 (n = 39)	2a (+, n = 25)	23.7 ± 4.6^	19.3 ± 3.7*^
		2b (–, n = 14)	18.4 ± 6.2	20.6 ± 7.4^
	ECF, L due value (n = 62) 17.3 ± 3.2			
ICF, L	Group 1 (n = 23)	1a (+, n = 12)	19.7 ± 5.9^	16.7 ± 6.6
		1b (– n = 11)	16.8 ± 7.3	17.6 ± 7.6
	Group 2 (n = 39)	2a (+, n = 25)	17.4 ± 7.8^	13.9 ± 7.9
		2b (–, n = 14)	14.5 ± 6.4	17.0 ± 8.4
	ICF, L due value (n = 62) 13.2 ± 7.5			
Phase angle, deg	Group 1 (n = 23)	1a (+, n = 12)	5.2 ± 0.8	5.8 ± 0.6*
		1b (– n = 11)	5.0 ± 1.1	4.7 ± 1.1
	Group 2 (n = 39)	2a (+, n = 25)	5.1 ± 0.9	5.8 ± 1.2*
		2b (–, n = 14)	5.8 ± 0.9	5.2 ± 0.9
	Normal value = 5.4—7.8			

Note: Group 1 — standard therapy, Group 2 — combined therapy, a — positive effect, b — no effect. * — the differences between two steps in the groups under study are significant, ^ — the differences between the indices of the subgroup under study and due values of this index are significant, $p < 0.05$.

During the therapy performed, the significant positive dynamics as normalization of fluid balance indices was noted in 12 patients (52%) in group 1 and 25 patients (64%) in group 2. Their initial values of BF, ECF, and ICF were higher and the initial PA was lower than the due values of these indices, $p < 0.05$. The increase in the fluid balance indices was observed in 11 patients (48%) of group 1 and in 14 patients (36%) of group 2, which reflected the remaining severity of the condition with the absence of therapeutic efficacy.

Table 4 gives the mean values of myocardial microalternation indices in the patients under examination. The significant positive dynamics manifested as a tendency to decreasing MMI was noted in 11(48%) patients of group 1 and in 22 (56%) patients of group 2. The absence of the therapeutic effect according to ECG-dispersion mapping was observed in 12 (52%) patients of group 1 and in 17 (44%) patients of group 2.

Table 4

MMI dynamics in the AHF patient groups under study at the examination steps

MMI,%	Group 1 (n = 23)	1a (+, n = 11)	32.7 ± 9.1	23.8 ± 8.8*
		1b (– n = 12)	28.7 ± 13.8	32.1 ± 12.9
	Group 2 (n = 39)	2a (+, n = 22)	31.8 ± 10.9	24.4 ± 9.4*
		2b (–, n = 17)	32.0 ± 8.9	40.3 ± 11.8*
	Normal level < 14			

The Kaplan-Meier survival curves in the first month of observation of the AHF patients in the groups under study are shown in Fig. 2A. 5 (22%) fatal cases were noted in group 1 of AHF patients and 2 (5%) fatal cases were noted in group 2. The fatality in the first month in the group with the combined therapy is significantly less than in the group with the standard therapy.

Figure 2B shows the survival time of AHF patients in the first year of observation in the groups under study. 8 (35%) fatal cases were noted in group 1 (n = 23) and 11 (28%) fatal cases were noted in group 2 (n = 39). No significant differences in the patient fatality rate were revealed for one year of observation in the groups under study in this patient setting. Thus, the application of external cardiosynchronized electrical stimulation for 7 days in the complex therapy of AHF patients decreases significantly the monthly fatality rate, but does not change the survival rate for one year in this patient setting.

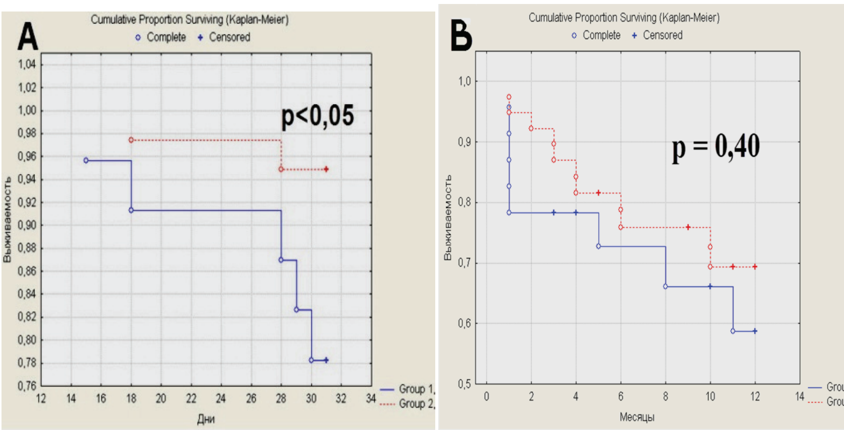

Fig. 2. (A) Survival time of AHF patients (n = 62) in the first month of observation in the groups under study, p < 0,05. (B) Kaplan-Meier survival curves in the first year of supervision over AHF patients in the groups under study, p = 0.40

Table 5 gives the diagnostic consideration of the death predictors obtained from the results of logistic regression for the first year of supervision over AHF patients. The predictive validity of the MMI+Age index equal to 101 and more was as follows: 84% (sensitivity) and 65% (specificity) and that of phase angle ≤ 5.2 deg. was 67% (sensitivity) and 65% (specificity). The predictive validity of the blood urea index ≥ 11 mmol/L was: 47% (sensitivity) and 88% (specificity) and that of Hb ≤ 100mg/L was 47% (sensitivity) and 92% (specificity).

Table 5

Diagnostic consideration of predictors in relation to the death in the first year of AHF patient supervision

Index	Sensitivity,%	Specificity,%
MMI+Age 101	84	65
Phase angle 5,2 deg.	67	65
Blood urea 11 mmol/L	47	88
Hb 100 mg/L	47	92

The mean value of the MMI+Age index in AHF patients was 101. The MMI + Age values in AHF patients were found to be related to the survival time. The survival curve of patients grouped according to the MMI+Age value is shown in Fig. 3. The survival time in the patients with MMI+Age ≥ 101 is significantly less than in remaining patients ($p = 0.001$).

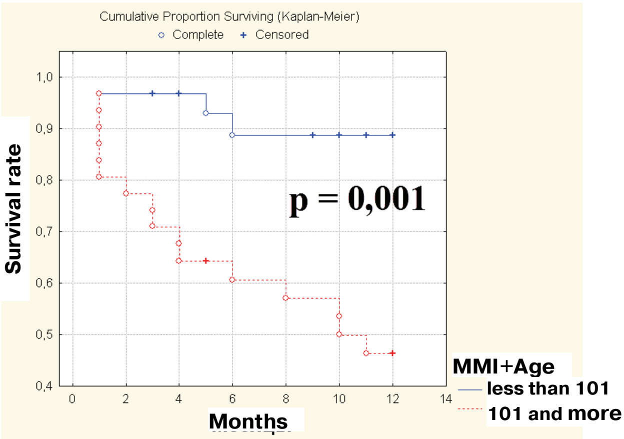

Fig. 3. AHF patient survival time (n = 62), the data are grouped according to the MMI + Age value. The survival time in the patients with MMI+Age 101 is significantly less than in remaining patients (p = 0.001). The risk of death is 10% in the patients with MMI + Age < 101 and is high (52%) in the patients with MMI + Age 101

Thus, external muscular counterpulsation can be used to improve the efficacy of conservative therapy in patients with acute heart failure (ischemia, myocardial infarction in the anamnesis, and dilated cardiomyopathy). A less efficacy is associated with a more pronounced comorbidity, including pneumonia and primary disease complications.

Discussion. Heart failure is a typical final of all cardiac diseases, the most cost-based disease of cardiology, and is characterized by an extremely low life quality, high fatality, poor prognosis and fast increase in the occurrence rate. CHF is a cause of about 20% of all hospital admissions among patients above 65 years old. According to the data from the Framingham study, 75% of males and 62% of females with CHF die during 5 years after establishing the diagnosis. The one-year fatality of patients with the clinically pronounced HF in the Russian Federation reaches the value of 26—29%.

The main causes of death upon chronic heart failure are decompensated heart failure and life-threatening ventricular dysrhythmia. Thus, decompensation of CHF is a quite severe condition requiring the immediate adequate care. Currently, CHF decompensation included into the term “acute heart failure”.

The latest advances in science and technology resulted in active introduction of transmyocardial laser and minimally invasive myocardial revascularization, neurostimulation transluminal electrical stimulation of nerves and spinal cord stimulation), different approaches using growth factors and cell technologies under the common name “alternative revascularization methods” for such patients. One of the most interesting techniques is additional treatment methods, such as external assisted circulation methods: enhanced external counterpulsation (ECP) and cardiosynchronized electrical myostimulation (CSEMS) [16—18]. By the orders of the Ministry of Health and Social Development of the Russian Federation Nos. 287 and 288 dated on 04/20/2007, the method of enhanced external counterpulsation is included to the standards of medical care for patients with stable angina and heart failure.

The numerous studies performed to date confirm a decrease in the clinical implications of the disease, improvement in the exercise tolerance in patients with refractory angina and there are data indicating a decrease in the myocardial ischemia signs when using noninvasive enhanced external counterpulsation. It was shown that, after the course of CSEMS, there occur a decrease in the mean arterial pressure, decrease in the total peripheral vascular resistance, an increase in the cardiac index and the minute heart work compared to the initial data. The changes in the intracardiac hemodynamic indices according to EchoCG revealed no significant changes after CSEMS compared to the initial parameters. However, when comparing with the control group, considerable changes in the dynamics of changes in the left ventricular volumes and in the myocardial contractility were noted in the group of CHD and CHF patients received the CSEMS treatment. It was shown that cardiosynchronized electrical myostimulation increases the exercise tolerance and total exercise time as compared with both the initial value and the control group [19]. The hemodynamic effects of external counterpulsation relating to the assisted circulation systems are studied in less detail [20—22].

The values of phase angle were first used to detect the metabolic disturbance and basal metabolic rate. The values of phase angles in healthy persons are usually in upper ranges and the less the values, the worse prognosis. The phase angle also decreases with the increase of years and depends not only on the nutritional status. For example, the PA values were lower upon diabetes, cancer toxication, during hemodialysis, in patients with hepatic cirrhosis. The phase angle values in patients with hepatic cirrhosis were found to be related to the survival time. In the patients with the phase angle less than 5.4, the survival time is significantly less than in remaining patients ($p < 0.001$) [24]. In patients with lung cancer, the mean phase angle was 4.57 deg and the survival rate of patients correlated good with this index (Toso *et al.*, 2000). In addition, the phase angle correlated significantly with the survival time upon sepsis (Kreymann *et al.*, 1995) and bacteremia (Schwenk *et al.*, 1988).

The character and degree of change of microalternations is a novel diagnostic region of signs reflecting the reserve of electrophysiological compensatory resources of myocardium. J. Kellett *et al*. showed that the MMI+Age values were found to be related to the survival time. The patients with MMI+Age ≥106 had a high risk of death [23].

Taking into account the data obtained, it is obvious that daily 60-min sessions of external muscular counterpulsation for 7 days in the complex therapy of AHF patients improve significantly the survival rate in the first month of observation. According to the data of Yurevichute G.I. et al., after three 10-day courses of CMC at intervals of 1.5—2 months with session duration of 60 min, in patients with CHF and decreased left ventricular ejection fraction, there was a significant increase in the left ventricular contractibility and improvement in the myocardial perfusion. Thus, due to the application simplicity, high therapeutic efficacy, and relative cheapness of the apparatus to be used in patients with circulatory deficiency under clinical or outpatient conditions, CMC can favor a rapid development of the high-tech medical care by a drastic reduction in the number of CHD complications and break of the pathologic relation with CHF, improvement in the quality and terms of CHD treatment, which along with other measures of the Ministry of Health of the Russian Federation will favor improvement of the life quality and life time of the citizens of the Russian Federation.

Based on the present study, we demonstrated the effect of a novel therapeutic approach, *viz*., application of the combination of traditional drug therapies and the method of external cardiosynchronized counterpulsation. A clinical improvement was also noted in the fluid balance indices. As in other studies using cardiosynchronized muscular counterpulsation, encouraging results on the clinical efficacy were obtained, which allow wider application of this technique in patients with different variants of acute heart failure. To assess more completely the efficacy of CMC in patients with different variants of AHF, subsequent studies are needed.

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ИССЛЕДОВАНИЕ ЭФФЕКТИВНОСТИ СИНХРОНИЗИРОВАННОЙ С ФАЗАМИ СЕРДЕЧНОГО ЦИКЛА ЭЛЕКТРИЧЕСКОЙ СТИМУЛЯЦИИ БОЛЬНЫХ С ОСТРОЙ СЕРДЕЧНОЙ НЕДОСТАТОЧНОСТЬЮ

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Работа посвящена актуальной проблеме — изучению эффективности внешней, синхронизированной с фазами сердечного цикла, мышечной контрпульсации (СМС) у пациентов с различными вариантами острой сердечной недостаточности. В исследование включены результаты обследования 62 пациентов с острой сердечной недостаточностью, которым проводится два варианта терапии: 1) только стандартную терапию (диуретики, нитраты и др.) и 2) в случае ее неэффективности в течение 12 часов — сочетание медикаментозной терапии с сеансами СМС в течение 7 дней. Клиническая оценка больных, находящихся на рассмотрении, характеризуется в группе со стандартной терапией как менее серьезная. Во 2-й группе пациентов, значительное улучшение показателей баланса жидкости было отмечено в ходе комбинированной терапии.

Ключевые слова: внешняя синхронизированная контрпульсация, сердечная недостаточность, дисперсионное картирование.