

Evaluation of Therapeutic Management of Severe Heart Failure by Leg Isometric Exercise (LIE) Test

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Abstract

To evaluate the therapeutic management of severe heart failure by using Leg Isometric Exercise (LIE) test, a study was carried out in the Department of New Method Diagnosis of Cardiovascular Diseases of the Scientific Research Institute of Cardiology, Tashkent, Former USSR during the period of July 1990 to October 1992. Study was done on 32 male patients of severe heart failure who have significantly reduced tolerability to the physical exercise. All of them are within the age of 32 to 65 years (mean age – 50.3±1.7 years). According to the functional status of these patients corresponds with functional class-II (n=12), FC-III (n=20) of NYHA. With the help of clinical evaluation and the results of repeated Echocardiography, which was conducted for evaluation of clinical effect in 10-12 days of starting of treatment, the patients were divided into two groups. Gr.-I (n=23) – patients with significant clinical therapeutic effect and Gr.-II (n=9) - patients without significant clinical therapeutic effect. It was revealed that parameter like exercise DBP decreased distinctly ($p<0.05$) in gr.I patients and resting DSC ($p<0.001$) and exercise DSC ($p<0.001$) after starting of treatment in relation to initial stages at rest and exercise. Therefore signs of clinical therapeutic effect of patients with severe heart failure were decrease of resting DSC and exercise DSC and also decrease of exercise DBP. It is to be noted that these parameters can be utilized by cardiologist in their practice for predicting therapeutic effect of patients with severe HF on the basis of the results of repeated LIE test.

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Introduction

Heart Failure (HF) continues to create an increasing social and economic burden worldwide as it remains one of the main reasons for morbidity and mortality of cardio-vascular diseases. In these relations, one of the main issues of cardiology is to increase the effectiveness of treatment of HF.

More acceptable for practical uses and for the clinical study, the new method for the effectiveness of the treatment of HF is the study of dynamics of functional classes of patients of HF according to the NYHA

classification¹. Effective treatment means the transformation of patient to subsequent less severe stages of functional class².

In this relation, the objective of designing an informative method of evaluation for the prognosis of treatment of severe HF patient is raised. In this case, the leg variant of isometric exercise is considered for solving such problems³.

Material and Methods

The study was carried out in the Department of New Method Diagnosis of Cardiovascular Diseases of the Scientific Research Institute of Cardiology, Tashkent, Former USSR during the period of July 1990 to October 1992. In this study, the patients were meticulously examined clinically with special attention to history of illness to distinguish its appropriate functional stage of heart failure.

Basic programs of study :

1. Clinical examination of the patients.
2. Resting 12- lead standard electrocardiography.
3. Resting echocardiography for the assessment of left ventricular function.
4. Leg Isometric Exercise (LIE) test for detection of preliminary response of isometric exercise on cardiovascular system.
5. The above mentioned stages of investigation were performed within 1-2 days, after which for patients with severe heart failure, introduce a drug treatment with combination of vasodilators, diuretics and cardiac glycosides along with ACE inhibitors.⁵
6. Repeated LIE on the 4th - 5th day since the beginning of therapy to study the possibility of forecasting the clinical effect of chosen line of treatment by means of this test.
7. Strict continuation of the therapy up to 10-12 days from the beginning of the treatment according to the initially chosen line of treatment.
8. Controlling clinical and instrumental evaluation of the effectiveness of the conducted therapy on 10-12 days of the treatment.
9. Comparison of the results of investigation of patients with the presence and absence of a trustworthy effect of treatment at initial state with the repeated isometric

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exercise test which was conducted at the initial stage of therapy.

10. Statistical analysis of the result.

Method of conduction of Leg Isometric Exercise (LIE) Test:

Patients were conducted leg isometric exercise with a special form of leg dynamometer. After placing the electrodes of Reoplethismogram, electro-cardiogram and probe of phonocardiogram the patient was kept in lying position in a specially made couch with which dynamometer (weight measuring machine) was fixed. The patient's legs were lifted up to the level of the dynamometer and kept at that level with the help of a footrest. Patient's shoulder was tightly fixed with the shoulder-rest in such way that the angle of the knee joint was in between 120-140 degree.

1. We have analyzed seven integral haemodynamic parameters and eight parameters of the pumping and contractile function of myocardium.⁷⁻¹¹ Out of these only two parameters are statistically significant and these are:

- i). Diastolic Blood pressure (DBP) in mm of Hg and
- ii). Diastolo-Systolic Co-efficient (DSC) of Impedence Cardiograph (IC) i.e. relation between maximum amplitude of the wave of diastolic and systolic complex recorded by IC in conditional unit. This data reflects as value of end diastolic pressure in left ventricle (LVEDP)¹².

2. Obtained value expressed in % relatively to resting condition and before treatment.

Results

Study includes 32 male patients of Chronic IHD with clear clinical manifestation of heart failure those who have significantly reduced tolerability to the physical exercise. All of them are within the age of 32 to 65 years (mean age – 50.3±1.7 years). The functional status of these patients corresponds with functional class-II (n=12), FC-III (n=20) of NYHA, having left ventricular systolic dysfunction according to Echocardiography (LVEF- < 40%)⁴ who have significantly reduced tolerability to the physical exercise. Maximum patients of these category experienced previous history of acute MI (n=31), ventricular arrhythmia was associated in 8 patients and 7 patients had hypertension (Table-01). The result obtained from data obtained analysis is documented below.

Table-I
Characteristics of Patients

Diagnostic criteria	n
Total Patient	32
Age	32-65
Post MI	31
NYHA FC-II	12
NYHA FC-III	20
Ventricular Arrhythmia	8
Arterial Hypertension	7

Table-II
Initial Echocardiographic Indices of the severe heart failure patients.

Indices	Groups		P
	Gr.-I (n=23)	Gr.-II (n=9)	
EDV (ml)	194.5 ± 9.0	192.8 ± 10.1	>0.1
ESV (ml)	127.2 ± 7.0	126.3 ± 11.2	>0.1
SV (ml)	64.1 ± 6.0	63.7 ± 6.0	>0.1
EF (%)	35.5 ± 2.7	34.7 ± 2.3	>0.1

Note: Brings absolute cardiac values (M±m) End Diastolic Volume (EDV), End Systolic Volume (ESV), Stroke Volume (SV), Ejection Fraction (EF) recorded in the initial (pre-treatment) stage of patients with(Gr.-I) or without (Gr.-II) effect of treatment .

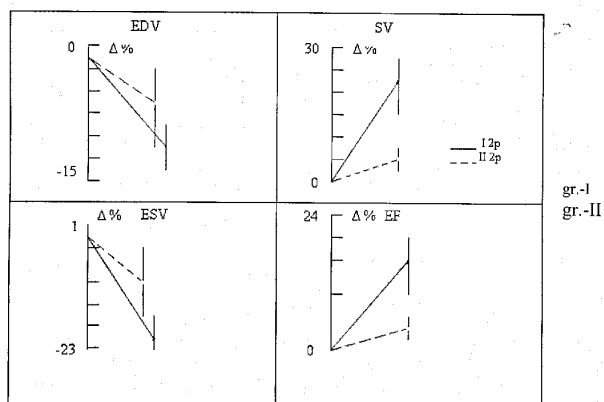


Fig.-01: Comparative characteristics of changes of echocardiographic parameters during treatment of patients with clear clinical manifestation of HF.

Note : Mean value of regulated parameters (M ± m) in percentage (%) in the initial stage before treatment.

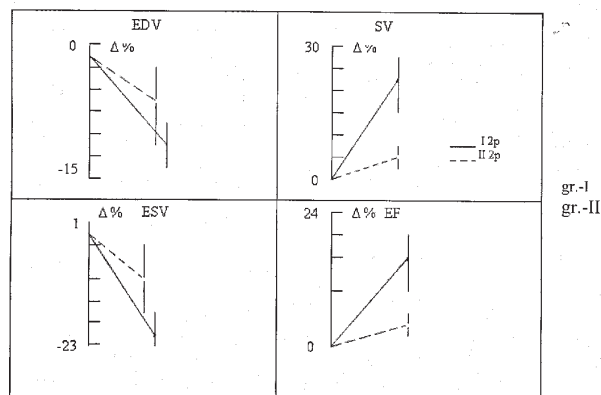


Fig.-02: Comparative characteristics of mean absolute value of exercise integral haemodynamic parameter of patients with clear clinical manifestation of HF.

Note: Mean absolute value of (M+m). SBP, DBP, HR, Diastolo-Systolic Co-efficient (DSC) registered during LIE before (A) and during (B) treatment of patients with early stage of HF.

Solid line indicates - Presence of therapeutic effect

Dotted line indicates -Absence of therapeutic effect

Table-III

Changes of exercise integral haemodynamic indices and cardiac productivity of patients with clear manifestations of HF after starting of treatment in relation to initial exercise parameters.

Indices	Gr.-I (n=23)	Gr.-II (n=9)	PI-II
HR (beat/min)	2.47±2.44	-2.92±7.35	>0.1
SI (ml/min)	10.02±9.70	6.14±12.76	>0.1
CI (L/min)	10.96±10.16	3.62±16.56	>0.1
SBP (mm of Hg)	6.93±2.43	-0.19±6.50	>0.1
DBP (mm of Hg)	-4.96±2.10*	2.04±4.65	>0.1
DP	3.64±3.94	-3.29±9.97	>0.1
Mean AP (mm of Hg)	1.48±2.22	0.72±4.98	>0.1

Note: Brings mean value (M±m) changes recorded in LIE after starting of treatment in % in relation to initial exercise parameters (%).

Intra-group trustworthy changes of parameter with the following symbol:

* - p<0.05; ** - p<0.02; # - p<0.01; ## - p<0.001

Table-04

Changes of exercises indices of pumping and contractile function of myocardium of patients with clear manifestation of HF after starting of treatment in relation to initial exercise parameters.

Indices	Gr.-I (n=23)	Gr.-II (n=9)	PI-II
Ve	10.58±8.42	3.98±17.79	>0.1
Index Matsuda	7.81±4.20	3.40±5.50	>0.1
Q/R-R	4.05±5.16	-0.30±7.45	>0.1
Index Heather	13.40±11.74	3.45±9.38	>0.1
Index Siegel	11.59±13.26	4.64±9.22	>0.1
Index Zubarev	14.96±12.33	5.87±19.36	>0.1
PEP/ET	26.81±16.92	0.18±8.40	>0.1
DSC	-18.21±3.66##	47.39±21.88	<.01

Note: Brings mean value (M±m) changes recorded in LIE after starting of treatment in % in relation to initial exercise parameters (Ä%).

Intra-group trustworthy changes of parameter with the following symbol:

· - p<0.05; ** - p<0.02; # - p<0.01; ## - p<0.001

Discussion

For the solution of basic tasks of the investigation, it was required to distribute subjects in different groups. This grouping of patients was conducted on the basis of clinical and instrumental characteristics, reflected in different degree of myocardial contractile dysfunction in initial condition and also the changes of inotropic reserve under the influence of treatment, which corresponds to the presence or absence of clinical improvement of the patients. Such distributions are based on verified division of patients in the form of presence or absence of therapeutic effect allows further conduction of comparative analysis of the results of LIE and explains the peculiarity of haemodynamic response depending on the initial stages of contractile response of myocardium of the patient in one hand and the changes of exercise haemodynamic index in early stage of treatment depending on conducted management scheme on the other hand. This can be adequately capable of achieving the prefixed goals that support or oppose the fact of possibility of use of LIE test in prognosis of the effectiveness of the treatment of HF and allows getting informative index of LIE test for the division of patients with or without effective treatment.

What was mentioned in the method, the group of patients with positive therapeutic effect was improved by the

treatment is documented by shifting of functional class (FC) from severe to moderate or moderate to mild. By the clinical evaluation of therapeutic effect, out of 12 patients of FC-II, 10 patients improved and shifted to FC-I (83.33%) and out of 20 patients of FC-III, 13 were improved and shifted to FC-II (65%). These improved patients (n=23) were considered as Gr.-I who has significant therapeutic effect. The rest of the 2 patients from FC-II and 7 from FC-III were considered as Gr.-II (n=9). This group of patients had no positive therapeutic effect. Here it should be mentioned that initial haemodynamic similarity between group-I and II patients is due to absence of statistically significant difference in initial echocardiographic parameter (Table.02). The results of clinical evaluation of treatment were supported by the data of the repeated echocardiogram performed at the moment of evaluation of therapeutic effect (fig.1). The statistically significant reduction of EDV ($p<0.001$) and ESV ($p<0.001$) and simultaneous increase of SV ($p<0.01$) and EF ($p<0.01$) observed in group-I patient. These were not found in group-II patients.

Therefore, conducted preparatory test allows division of patients in two groups i.e. patients with or without significant therapeutic effect of HF. The previous division of patients was utilized in later analysis in the study of informativeness of LIE test for early detection of patients with or without therapeutic effects.

Analogical results of LIE and performed data before treatment in this relation take place positive chronotropic reaction to hypertension. Together with patients' with gr.-I shows slightly increase DBP in exercise ($p < 0.05$), where gr.-II patients changes of these indices keep in a level, recorded in initial condition. It should be noted that in the patients with severe HF, the absolute value of DSC at rest were already elevated (for gr.-I patients, 0.78 ± 0.1 c.u. and for patients of the II gr. 0.87 ± 0.08 c.u.), which testifies the considerable reduction of the contractile function of the myocardium. These data corresponds to a certain extent, with the results of the analyses of the initial echocardiographic indices.

Comparative analysis of average initial value of DSC and integral haemodynamic parameters recorded at rest in severe HF has not revealed statistically significant inter difference. The initial LIE in both groups patients with severe HF (fig.2) shows approximately the same response. Increase of HR was accompanied by the considerable increase of DSC.

The discovered absence of inter-group difference of the initial haemodynamic indices, and also DSC recorded both at rest and at the initial LIE gives ground to use these

indices for forecasting the therapeutic effects in the patients of a given category.

The analysis of resting haemodynamic changes in early stages of treatment showed (fig.01) that in patients with the presence of a therapeutic effect there was a distinct and highly trustworthy reduction of initially elevated DSC ($19.62 \pm 4.56\%$, $P < 0.001$), which testified to the improvement of the functional condition of the myocardium. It was accompanied by a negligible, but statistically trustworthy lowering of HR testifying to the definite improvement of chronotropic reserve of this patients.¹³ In contrast, the gr.-II patients did not notice any trustworthy changes. The obtained data are indicative of the fact that lowering of the DSC at rest is one of the necessary conditions of a therapeutic effect for patients with a severe degree of HF.

Truly the comparative analysis of circulatory dynamics of exercise parameter under the influence of treatment, calculated in relation to exercise parameter recorded before treatment (Table -03, 04), revealed significant inter-group difference in the changes of exercise DSC of this category patients. The difference in exercise DSC in gr.-I patients was statistically significant ($18.21 \pm 3.66\%$, $p < 0.001$), which was not observed in gr.-II patients, changes of this parameter consists of 47.39 ± 21.88 ($p < 0.05$), which can be explained as deterioration of functional condition of myocardium. Among other haemodynamic parameters, recorded against the background of the treatment a trustworthy inter-group difference was revealed only in relation to the changes of the exercise DBP, calculated in comparison to the initial exercise DBP. In the gr.-I patients a statistically trustworthy reduction of this index was observed ($4.96 \pm 2.1\%$, $P < 0.05$), while in the gr.-II patients this changes were statistically insignificant ($2.04 \pm 4.56\%$, $P > 0.1$) (Table -03, 04). It was already shown that, this category of patients received a more combined therapy including peripheral vasodilators with both arteriolar and venous action, as well as diuretic preparations. In these circumstances, one can consider the successful implementation of combination therapy for the given category patients depends on the lowering of DSC at rest and on exercise which signifies the hypotensive effect of this preparation during exercise.

Therefore, signs of clinical therapeutic effect of patients with severe HF were decrease of resting DSC and exercise DSC calculated in relation to initial exercise DSC, and also decrease of exercise DBP.

This parameter can be use in practice by a cardiologist for early prognosis of therapeutic effect in patients with clear clinical manifestation of HF on the basis of results of repeated LIE tests.

APPENDIX

Discrimination model of equations and criteria for the prognosis of the therapeutic effect according to the data of leg isometric tests:

Types of conclusion	Patients with severe HF $D = 0.17 \cdot \Delta \% \text{DBP}_{\text{ex.}} + 0.36 \cdot \Delta \% \text{DSC}_{\text{rest}} + 0.7 \cdot \Delta \% \text{DSC}_{\text{ex.}}$
1. Expected authentic effect of chosen method of treatment	≤ -0.529
2. Expected absence of an effect of a chosen method of treatment, which is necessary to be corrected.	≥ 1.35
3. The doubtful expected effect of the treatment that is necessary to conduct additional investigations	$> -0.529 < 1.35$

The obtained data show that for the prognosis of the therapeutic effect of patients with HF according to the results of LIE tests, it is necessary to take into account several informative parameters which allow separating the patients with the presence or absence of therapeutic effect. In the selected patients the samples satisfied the criteria of the normal distribution, and the patients with the presence or absence of the therapeutic effect according to the chosen informative indices showed a distinct statistically authentic difference. These conditions are adequate for the use of the technique to distinguish and analyze and to design multidimensional mathematical model, in purpose to separate (discriminate) the patients with an expected and doubtful therapeutic effect. The discrimination analysis allowed us to design a mathematical model for evaluation of therapeutic efficiency of patients with severe HF by using the results of LIE. Here, to design the model the dynamics of DSC at rest and exercise, as well as the dynamics of the exercise DBP under the influence of treatment were used for the patients with severe HF. These parameters are used in following formula: $D = 0.17 \cdot A + 0.36 \cdot B + 0.7 \cdot C$

Where, A – changes of DBP in exercise during treatment in relation to resting condition; B – changes of DSC at rest during treatment in relation to initial condition; C – changes of DSC in exercise during treatment in relation to initial exercise DSC; D – discrimination function.

Conclusions

Repeated LIE test performed with a maximum possible exertion and conducted before and at the initial stages of treatment is adequate for the solution of problems of forecasting the therapeutic effect of patients with IHD complicated by HF.

The most informative rheoplasmographic index for evaluation of a functional state of the myocardium allows obtaining clinically significant information about patient with HF is DSC recorded in patients at rest. A considerable increase of this index at rest and on mild isometric exercise is indicative of a severe degree of HF.

The early signs of the therapeutic efficacy of patients with severe degree of HF are the reduction of initially elevated DSC both at rest and on exercise accompanied by a distinct lowering of the exercise DBP.

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