Use of Taurine During Rehabilitation After Cardiac Surgery

Evgeny Averin

Abbreviations

AH	Arterial hypertension
BID	"Bis in die" twice a day
BP	Blood pressure
CH	Concentric hypertrophy
CHD	Coronary heart disease
CHF	Chronic heart failure
CI	Cardiac index
CR	Concentric remodelling
ECG	Electrocardiogram
EDD	End-diastolic diameters
EDV	End-diastolic volumes
EF	Ejection fraction
EH	Eccentric hypertrophy
ESD	End-systolic diameters
ESV	End-systolic volumes
HDL-C	High-density lipoprotein cholesterol
HR	Heart rate
IVST	Inter-ventricular septum thickness
LDL-C	Low-density lipoprotein cholesterol
LVEF	Left ventricular ejection fraction
LVMM	Left ventricular myocardial mass
LVPW	Left ventricle posterior wall thickness

E. Averin (✉)
Department of Cardiology of Faculty of Postgraduate Education,
Russian National Research Medical University, Moscow, Russia
e-mail: averin76@bk.ru

J. Marcinkiewicz, S.W. Schaffer (eds.), *Taurine 9*, Advances in Experimental Medicine and Biology 803, DOI 10.1007/978-3-319-15126-7_51

NG	Normal geometry
NYHA	New York heart association
RWT	Relative walls thickness
SI	Systolic index
SV	Systolic volume
QoL	Quality of life
TG	Triglyceride
WAM	Well-being, activities and mood

1 Introduction

Presently, Russian cardiac surgery care is experiencing rapid development. A growing number of patients have gained access to high-technology cardiac surgery. Meanwhile, a successful operation is not always a guarantee of a patient's return to his/her working and social activities. In this context, both the success of an operation and the patients' rehabilitation at health resorts and during out-patient period care should be attentively addressed.

Cardiac surgery involving cardiopulmonary bypass leads to impaired myocardial metabolism. Indeed, Suleiman et al. (1993) demonstrated a reduction in taurine levels in myocardial biopsy samples following cardioplegia. The authors suggested the use of Taurine-based drugs both prior, during and after the operation for the purpose of limiting myocardial ischemic damage.

Doddakula et al. (2010) demonstrated the anti-inflammatory and anti-arrhythmic effects of Taurine cardioplegia solutions during post-surgical care.

The explorative study of Sahin et al. (2011) evaluated the role of taurine as an agent for decreasing ischemic cellular damage, presumably due to its antioxidant actions.

In the literature, we could not reveal any studies that have employed taurine during the recovery period after cardiac surgery.

This study aimed to define the influence of taurine on key clinical, instrumental, laboratory and psychological measurements during the rehabilitation period after cardiac surgery.

2 Methods

2.1 Two-Dimensional Transthoracic Echocardiography

The assessment of cardiac morpho-functional parameters included the quantitative 2-dimension heart ultrasound examination with the use of standard technique Lang et al. (2006) using the ultrasonograph ACUSON X128P/10 m (USA) with V4C transducer. The following parameters were measured: linear dimensions of the

cardiac cavities (left atrium and right ventricle anterior-posterior diameters, left ventricle end-systolic (ESD) and end-diastolic diameters (EDD)), left ventricle end-systolic (ESV) and end-diastolic volumes (EDV), left ventricular ejection fraction (LVEF) (using the Teicholz formula [L.E. Teicholz et al.]), inter-ventricular septum thickness (IVST), left ventricle posterior wall thickness (LVPW), left ventricular myocardial mass (LVMM) and LVMM index (using the Devereux formula [Devereux R.B. 1986]).

The type of the left ventricular hypertrophy was determined:

- normal geometry (NG) was recorded in patients with normal values of LVMM (LVMM index, calculated as LVMM to the body area (calculated using the de Bois nomogram) ratio) and the value of the left ventricular relative walls thickness (RWT), calculated with the use of the formula (IVST + LVPW) × 100 %/EDD <45 %
- eccentric hypertrophy (EH)—increased LVMM index, RWT <45 %
- concentric hypertrophy (CH)—increased LVMM index, RWT >45 %
- concentric remodelling (CR) of the left ventricle—normal LVMM index, RWT >45 %.

The following functional parameters were calculated: left ventricular systolic volume (SV), systolic index (SI) calculated as SV to the body area ratio, cardiac index (CI) calculated from the production of SI and heart rate (HR), ejection fraction (EF).

2.2 The Minnesota Living with Heart Failure Questionnaire

The Minnesota Living With Heart Failure Questionnaire was used for the evaluation of subjects' quality of life.

This questionnaire included 21 sub-questions. The unique main question was proposed: "Did your heart failure prevent you from living as you wanted during the past month (4 weeks) by…?", with further clarifying sub-questions (Appendix 1). The patient had to mark the answer using the 6-point scale for 0–5. The lowest part of the sheet contained the clarification of the point assignment: 0—no; 1—very little; 2—a little; 3—moderate; 4—much; 5—very much. The patient had to delete the selected score.

The results were processed using the score values. The total value for the whole questionnaire was derived.

2.3 Well-Being, Activity, Mood Test

WAM-test was used for the purpose of the operative differential self-assessment of subjects' functional status using three classes of signs: well-being, activity, mood. The subject had to match his/her current state with the range of signs, characterizing

each category, and to assess the intensity of each sign using the 7-point scale, on the special sheet. The mean values of three categories of signs assessed in points were calculated.

2.4 Statistic Analysis

The computerized analysis of the present study was conducted with the use of the package of applied statistical programs SAS (Statistical Analysis System, SAS Institute Inc., USA) using the parametric and non-parametric variation statistics dependent on the measurement scales of each factor.

For the continuous values, the mean values, standard deviations, mean errors, median, interquartile range etc. were calculated. For the nominal values ("yes/no") or the range values, the rate of each ordinal score was calculated in percents.

The analysis of intergroup differences for the continuous values included the calculation of Student's t-tests for independent samples using the corresponding equations, in three different modifications based on the statistical distribution of the specific measures.

In the case of binary factors the significance of difference of the rate of specific factors in two compared groups was assessed with the use of t-test modified with the *arcsin* Fisher transformation.

3 Results

3.1 Design and Basic Information

3.1.1 Materials and Methods

The study involved 48 patients ranging in age from 21 to 62 years who suffer from chronic heart failure (CHF) and have undergone cardiopulmonary bypass surgery. The patients were examined and treated at Volgograd Regional Cardiology Center. Twenty-four patients received the cardiotonic drug Dibicor (Pik-Pharma, Russian Federation), including 18 men (75 %) and 6 women (25 %). The remaining 24 patients composed the control arm.

Exclusion criteria for the study were as follows: diabetes, progressive angina pectoris, uncontrolled CHF, uncontrolled malignant arterial hypertension (AH), symptomatic hepatic and renal failure, anaemia, cancer. The study protocol was approved by the Regional Ethics Committee.

The comparative characteristics of CHF in the active and placebo groups during the post-surgical period are presented in the Table 1.

The taurine group of patients with ischemic CHF consisted of 12 men with coronary heart disease (CHD) undergoing coronary bypass surgery. The age of the

Table 1 Comparative characteristics of study subjects with CHF

	Coronary heart disease		Heart valve defects	
Measures	Taurine	Placebo	Taurine	Placebo
Number of patients	n = 12	n = 12	n = 12	n = 12
Gender				
Male	12 (100 %)	12 (100 %)	6 (50 %)	6 (50 %)
Females	0	0	6 (50 %)	6 (50 %)
Age (years)	55.9 ± 1.4	54.6 ± 1.5	43.5 ± 1.3	42.7 ± 1.5
Disability	5 (41.7 %)	5 (41.7 %)	6 (50 %)	6 (50 %)
Employed	6 (50 %)	6 (50 %)	6 (50 %)	6 (50 %)
Heart failure functional class (NYHA)	1.9 ± 0.1	1.9 ± 0.1	2.0 ± 0.1	2.1 ± 0.1
Arterial hypertension	10 (83.3 %)	10 (83.3 %)	4 (33.3 %)	4 (33.3 %)
Kidney disorder	4 (33.3 %)	4 (33.3 %)	3 (25 %)	3 (25 %)
Myocardial infarction	8 (66.6 %)	8 (66.6 %)	0	0

patients varied from 47 to 62 years (the mean age was 55.9 ± 1.4 years). Half of the patients were employed. Before surgery, the NYHA functional classification of heart failure corresponded to 1.9 ± 0.1. The angina pectoris functional class was assessed as 3.1 ± 0.1, with 66.6 % of the patients having a history of myocardial infarction. The mean number of bypasses implanted was 3.2 ± 0.3. The placebo group of the ischemic CHF patients included 12 men with CHD who underwent coronary bypass surgery. The age of the placebo patients varied from 47 to 62 years (the mean age was 54.6 ± 1.5 years). Half of the patients were employed. Before surgery, the NYHA functional classification of heart failure was 1.9 ± 0.1. The angina pectoris functional class before the surgery was 3.0 ± 0.1, with 66.6 % of the patients having a history of myocardial infarction. In the mean, 3.1 ± 0.3 of bypasses were implanted. The average period between the first diagnosis of CHD and surgery in both study groups was 5.1–5.3 years.

The taurine arm of the CHF study of patients with acquired heart valve defects involved 12 patients undergoing valve replacement surgery. Women constituted half of the patients (six men and six women). The study patients varied from 29 to 61 years of age (the mean age was 43.5 ± 1.3 years, with the mean age of men being 42.1 ± 0.8 and women 45.4 ± 1.2). Half of the patients were employed. The average value of the NYHA functional class of heart failure before surgery was 2.0 ± 0.1. One-valve and two-valve disease were diagnosed in nine patients (75 %) and three patients (25 %), respectively. Twelve CHF patients who underwent surgery due to acquired heart valve disease, entered the placebo group. The numbers of men and women in this group were equal (six men and six women). The study patients were 29–61 years old (the mean group age was 42.7 ± 1.5 years, the mean age of men was 42.0 ± 1.1 and women 44.7 ± 1.7 years). Half of the patients were employed. Before surgery, the average value of the NYHA heart failure functional class was 2.1 ± 0.1. One-valve and two-valve diseases were diagnosed in nine patients (75 %) and in

three patients (25 %), respectively. The mean period between diagnosis and surgery in the two groups of patients with heart valve malformations was 10.7 ± 3.3 and 10.3 ± 3.1 years, respectively.

In general, the number of cases of arterial hypertension was comparable among the CHF patients in the taurine and placebo groups. The two groups of patients included an equal number of cases of postcardiac injury syndrome and post-haemorrhagic anaemia, as well as cases of laryngitis associated with tracheal intubation.

Taurine was administered at a dose of 250 mg BID for a period of 3 months. Treatment started during in-hospital stay, 3 weeks after surgery, at a point in which the state of the patients was adequately stable. The subjects were placed on medication during their sanitarium treatment and in community clinics.

The treatment of CHF was conducted in accordance with the national recommendations (of the Russian Scientific Society of Cardiology and Society of Specialists in Heart Failure) establishing the principles of CHF diagnosis and treatment (National guideline on the diagnosis and treatment of CHF 2003).

The follow-up and examination were conducted at the cardiac surgery hospital (Visit 1), 3 weeks after cardiac surgery (coronary bypass surgery or valve replacement surgery). After being discharged from the hospital, the patients were further treated at the health resort "Volgograd". Following the rehabilitation in a sanitarium, the subjects continued follow-up with cardiologists and general practitioners at their place of residence. Three months after discharge from the hospital, the study subjects completed Visit 2 at the Rehabilitation Department of the Center for Cardiac Surgery.

During Visit 1, patients' status was assessed (Fig. 1).

During Visits 1 and 2, the clinical examination was conducted, including blood pressure (BP) measurement, assessment of subjects' well-being, activities and mood (with the use of WAM-test) and assessment of the quality of life using the Minnesota Living With Heart Failure Questionnaire. A 12-lead electrocardiogram (ECG) was recorded in each subject. Laboratory blood tests were conducted.

Within safety assessment, any adverse events were recorded, as well as the serious adverse events (death, risk of death, events requiring hospitalization or prolonged

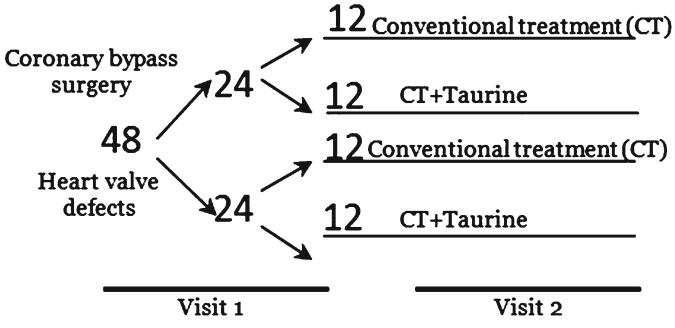

Fig. 1 Subjects' distribution in the study groups

hospitalization, events leading to permanent or significant disability and/or incapacity to work). Adverse events included any negative signs, symptoms or medical conditions (diseases) that developed after the start of treatment with the study drug that was independent of the presence of the study treatment (drug).

3.2 Heart Valve Replacement Surgery Group

Patients with heart valve malformations enrolled into the active treatment and placebo arms had the similar symptoms of CHF. At the baseline, New-York Heart Association (NYHA) class of the heart failure was 2.0±0.1 in the active treatment arm and 2.1±0.1 in the conventional treatment (control) arm. The results of the 6-min walk test did not reveal any significant differences between the active and control arms (362.7±63.4 m vs. 367.3±98.1 m, respectively).

The decrease in NYHA CHF functional class amounted to 16.5 % in the active treatment arm ($p<0.05$) and to 4.8 % in the control arm.

EF increased by 7.6 % in the active treatment group ($p<0.05$), compared with 2.4 % in the control group. The inter-ventricular septum thickness was reduced 5.7 % in the taurine group ($p<0.005$) and by 1.9 % n the control group. Treatment with taurine caused a 10.6 % reduction in inter-ventricular septum thickness ($p<0.005$) compared with a 2.7 % reduction in the control group. Notably, at the end of the study the left ventricular posterior wall thickness (LVPW) was significantly smaller by 6.5 % ($p<0.001$) in the control arm (Table 2).

LVMMI decreased by 5.9 % in the active treatment group ($p<0.05$) compared with 2.9 % in the control group. At the end of the study, LVMMI was significantly lower (by 4.5 %) in the active treatment group compared with the control group ($p<0.05$).

The level of TG decreased by 12.5 % in the active treatment group ($p<0.05$) relative to the control group, whose levels remained unchanged. At the end of the study, TG levels were significantly lower (by 12.5 %) in the active treatment group compared with the control group ($p<0.05$) (Table 3).

3.3 Coronary Bypass Group

The patients undergoing coronary bypass surgery were divided into either the active treatment or the placebo arms; both groups exhibited similar clinical symptoms of CHF. The baseline NYHA heart failure functional class was 1.9±0.1 in both arms. The results prior to treatment for the 6-min walk test did not reveal any differences between the active treatment and control treatment arms (407.7±71.9 m vs. 406.1±73.4 m, respectively).

The percentage decrease of the NYHA CHF functional classification was 15.8 % in the active treatment arm ($p<0.01$) and 5.3 % in the control arm.

Table 2 Morpho-functional heart measures in patients undergoing valve replacement surgery due to the heart valve defects

	Taurine		Placebo	
Measures	Before treatment	After treatment	Before treatment	After treatment
SV (mL)	77.1±4.5	70.2±4.8*	74.4±4.8	72.8±2.6
EF (%)	57.9±4.3	62.3±5.1^{K}	58.8±5.1	60.2±5.0
LVEDD (mm)	52.2±1.1	51.3±1.3	51.9±1.2	51.1±1.1
LVESD (mm)	35.1±1.3	34.4±1.1	34.8±1.2	34.5±1.1
IVST (mm)	10.6±0.4	10.0±0.4*	10.5±0.4	10.3±0.3
LVPW (mm)	11.3±0.4	10.1±0.5^{Q}	11.1±0.5	10.8±0.2^{F}
Aorta (mm)	36.5±1.0	36.2±1.1	36.6±1.1	36.4±0.5
PA (mm)	23.6±0.7	23.3±0.4	23.7±0.4	23.5±0.5
LA (mm)	47.7±1.4	45.5±1.3*	47.2±1.3	46.7±1.1^{H}
RA (mm)	40.0±1.1	38.1±1.1^{Y}	39.9±1.1	39.1±1.1^{H}
LVMMI (g/m^2)	136.9±6.8	128.8±7.7^{K}	138.8±9.2	134.8±4.3^{H}

SV systolic volume, *EF* ejection fraction, *FS* percent fractional shortening, *RV* right ventricle, *LVEDD* left ventricle end-diastolic diameter, *LVESD* left ventricle end-systolic diameter, *IVST* inter-ventricular septum thickness, *LVPW* left ventricular posterior wall, *PA* pulmonary artery, *RA* right atrium, *LVMMI* left ventricular myocardial mass index

$^{K}p<0.05$; *$p<0.005$; $^{Y}p<0.002$; $^{Q}p<0.001$—vs. the baseline level

$^{H}p<0.05$; $^{Z}p<0.005$; $^{F}p<0.001$—vs. patients in Taurine arm

Table 3 Morpho-functional heart measures in patients undergoing valve replacement surgery due to the heart valve defects

	Taurine		Placebo	
Measures	Before treatment	After treatment	Before treatment	After treatment
Total cholesterol (mmol/L)	5.4±1.1	5.2±0.9	5.3±0.8	5.2±0.9
LDL-C (mmol/L)	4.2±0.9	3.9±0.7	4.2±0.8	4.0±0.7
HDL-C (mmol/L)	1.1±0.4	1.2±0.3	1.1±0.4	1.1±0.4
TG (mmol/L)	2.4±0.3	2.1±0.3^{K}	2.4±0.5	2.4±0.3^{H}

$^{K}p<0.05$—vs. the baseline (before treatment) level

$^{H}p<0.05$—vs. patients in the Taurine group

LVEF increased by 9.0 % in the active treatment group ($p<0.05$), compared with a 1.5 % increase in the control group. The inter-ventricular septum thickness was reduced by 6.5 % in the taurine group ($p<0.002$) and by 2.8 % in the control group. The left ventricular posterior wall thickness was reduced by 7.2 % in the taurine group ($p<0.002$) and by 2.7 % in the control group. Notably, at the end of the study the IVST and LVPW thickness were significantly smaller than those in the control arm; the reduction was 3.8 % ($p<0.05$) and 4.6 % ($p<0.05$), respectively. LVMMI was decreased by 5.8 % in the active treatment group ($p<0.05$), compared with 2.9 % in the control group (Table 4).

Table 4 Morpho-functional heart measures in patients undergoing the coronary bypass surgery

	Taurine		Placebo	
Measures	Before treatment	After treatment	Before treatment	After treatment
SV (mL)	75.3±4.1	73.8±4.3	75.1±4.3	73.5±3.1
EF (%)	51.1±5.3	55.7±5.2^{K}	52.1±5.2	52.9±5.1
LVEDD (mm)	50.8±1.1	50.9±1.1	50.9±1.2	51.1±1.1
LVESD (mm)	33.8±1.3	33.4±1.1	34.0±1.2	33.8±1.1
IVST (mm)	10.8±0.4	10.1±0.4^{Y}	10.8±0.4	10.5±0.3^{H}
LVPW (mm)	11.1±0.4	10.3±0.5^{Y}	11.1±0.5	10.8±0.2^{H}
Aorta (mm)	33.8±1.0	34.1±1.1	33.6±1.1	34.0±0.5
PA (mm)	20.6±0.7	20.3±0.4	20.7±0.4	20.5±0.5
LA (mm)	41.2±1.3	40.5±1.3	41.1±1.3	40.6±1.1
RA (mm)	34.3±1.1	34.1±1.1	34.4±1.1	34.2±1.1
LVMMI (g/m^2)	137.1±8.7	129.1±8.7^{K}	138.1±9.1	134.1±7.1

$^{K}p<0.05$; $^{Y}p<0.002$—vs. the baseline (before treatment) level
$^{H}p<0.05$—vs. patients in the Taurine group

Table 5 Morpho-functional heart measures in patients undergoing the coronary bypass surgery

	Taurine		Placebo	
Measures	Before treatment	After treatment	Before treatment	After treatment
Total cholesterol (mmol/L)	4.9±0.9	4.6±0.8	4.9±0.8	4.7±0.9
LDL-C (mmol/L)	3.6±0.6	3.4±0.6	3.6±0.8	3.5±0.7
LDL-C (mmol/L)	1.1±0.3	1.2±0.3	1.1±0.4	1.1±0.4
TG (mmol/L)	2.2±0.3	1.9±0.3^{K}	2.4±0.5	2.3±0.3^{H}

$^{K}p<0.05$—vs. the baseline (pre-treatment) level
$^{H}p<0.05$—vs. patients in the Taurine group

The level of TG decreased by 13.6 % in the active treatment group ($p<0.05$), compared to a decrease by 4.2 % in the control group. At the end of the study, TG levels were significantly lower (by 17.4 %) in the active treatment group than the control group ($p<0.05$) (Table 5).

3.4 The Influence of Taurine on the Quality of Life and Psychological Status of Patients with CHF, Undergoing the Cardiac Surgery with Cardiopulmonary Bypass

The general improvement of the quality of life (QoL) in patients with CHF was 22.6 % on average ($p<0.05$), vs. 16.6 % in the placebo arm. Meanwhile, QoL improved by 17.7 % among male subjects and by 27.7 % among women ($p<0.05$).

Table 6 Time-related changes of the Quality of Life in patients with CHF in the Taurine arm

	Quality of Life, score			
	Taurine		Placebo	
Name	Before treatment	After treatment	Before treatment	After treatment
Group mean	34.1±2.3	26.4±2.5*	33.7±2.1	28.1±2.4
Males	31.6±4.9	26.0±5.9	31.3±4.6	27.0±5.4
Females	38.2±5.0**	27.6±5.2*	37.2±5.0	31.7±5.2
Heart valve defects group				
Group mean	35.1±2.3	26.9±2.5*	35.3±2.3	29.5±2.5
Males	28.1±2.7	24.3±3.1	28.3±2.6	26.1±2.9
Females	38.2±5.0	27.6±5.2*	37.2±5.0	31.7±5.2
Coronary bypass group				
Group mean (men)	33.1±2.4	24.9±2.5*	32.6±2.4	27.3±2.5

*$p<0.05$ vs. pre-treatment values
**$p<0.05$ vs. male subjects

In the placebo arm of patients with CHF the changes were not significant (13.7 and 14.8 %), in line with little improvement in CHF. The time-related changes in the quality of life in the taurine arm of CHF patients are presented in the Table 6.

QoL improvement in the valve defect group was 23.5 % ($p<0.05$) vs. 16.4 % in the placebo arm. In the taurine arm of CHD patients, QoL improved 24.8 % ($p<0.05$) vs. 16.3 % in the placebo arm. Among male patients, QoL improved 13.5 % vs. 22.8 % among women ($p<0.05$), while in the placebo group the respective values were 7.8 % and 18.1 %.

Thus, 3-month taurine treatment led to 22.6 % improvement in the quality of life ($p<0.05$). Male patients in the heart valve defect group had a better baseline quality of life value compared with women. However, they demonstrated a smaller increase in QoL: 13.5 % vs. 22.8 %, respectively.

3.5 Time-Related Changes of the Results of "Well-Being, Activity, Mood" Test

At the end of taurine treatment, the "Well-Being" score of the WAM-test demonstrated a 10.6 % improvement of the group average ($p<0.05$) vs. 6.4 % in the placebo group. The analysis of gender subgroups revealed larger improvement of the Well-Being factor in women: 12.8 % ($p<0.05$). In male patients, the growth of this value was not significant (6.5 %). In the placebo arm, the corresponding changes were 8.5 % and 4.3 %, respectively (Table 7).

At the end of taurine treatment, the group mean score of well-being among the patients with heart valve defects had increased 6.5 % ($p<0.05$) vs. 4.3 % in the placebo arm. The improvement in well-being rose 12.8 % among women and 6.5 % among men in the taurine arm, but only 8.5 % and 2.2 %, respectively, in the placebo arm.

Table 7 The Well-Being score of WAM-test in CHF patients enrolled into the taurine arm

Name	Well-Being, score			
	Before taurine treatment	After taurine treatment	Before placebo treatment	After placebo treatment
Group mean	4.7±0.1	5.2±0.2*	4.7±0.1	5.0±0.2
Males	4.6±0.2	4.9±0.2	4.6±0.2	4.8±0.2
Females	4.7±0.2	5.3±0.1*	4.7±0.2	5.1±0.1
Heart valve defects group				
Group mean	4.7±0.1	5.0±0.1*	4.7±0.1	4.9±0.2
Males	4.6±0.1	4.9±0.2	4.6±0.1	4.7±0.2
Females	4.7±0.2	5.3±0.1*	4.7±0.2	5.1±0.1
Coronary bypass group				
Group mean (men)	4.6±0.1	5.2±0.1*	4.7±0.1	5.1±0.2

*$p<0.05$ vs. pre-treatment values

Table 8 The activity score of WAM-test in CHF patients enrolled into the taurine arm

Name	Activity, score			
	Before taurine treatment	After taurine treatment	Before placebo treatment	After placebo treatment
Group mean	4.6±0.1	5.1±0.1*	4.6±0.1	5.0±0.2
Males	4.6±0.2	5.1±0.2*	4.6±0.2	4.9±0.2
Females	4.7±0.1	5.2±0.1*	4.7±0.1	5.1±0.2
Heart valve defects group				
Group mean	4.7±0.1	5.2±0.1*	4.7±0.1	5.1±0.1
Males	4.6±0.1	5.1±0.1*	4.6±0.1	5.0±0.1
Females	4.7±0.1	5.2±0.1*	4.7±0.1	5.1±0.2
Coronary bypass group				
Group mean (men)	4.5±0.1	5.0±0.1*	4.5±0.1	4.9±0.2

*$p<0.05$ vs. pre-treatment values

The baseline level of well-being in patients undergoing coronary bypass surgery was similar to the patients with the heart valve defects. However, the former group demonstrated higher (6.1 %) improvement of well-being following taurine treatment ($p<0.05$).

The subjects enrolled in the taurine arm demonstrated a 10.9 % ($p<0.05$) increase 1 in the "Activity" score compared with 8.7 % in the placebo arm. Among women, this value was 2.0 % higher than in men both before and after taurine treatment, with the mean value being 10.6 %. The increase in the score in the placebo arm was 8.5 % (Table 8).

The analysis of diagnosis-based subgroups showed higher "Activity" scores in patients with heart valve defects both before and after taurine treatment (4.4 %), compared to the CHD group; the post-treatment increase in the taurine arm was 11.1 %.

Table 9 The Mood score of WAM-test in CHF patients enrolled into the taurine arm

Name	Mood, score			
	Before taurine treatment	After taurine treatment	Before placebo treatment	After placebo treatment
Group mean	5.2±0.1	5.6±0.1*	5.2±0.1	5.4±0.1
Males	5.3±0.2	5.6±0.1	5.3±0.2	5.5±0.1
Females	5.1±0.1	5.5±0.2*	5.1±0.1	5.3±0.2
Heart valve defects group				
Group mean	5.3±0.1	5.7±0.1*	5.3±0.1	5.6±0.1
Males	5.3±0.2	5.7±0.1	5.4±0.2	5.7±0.1
Females	5.1±0.1	5.5±0.2*	5.1±0.1	5.3±0.2
Coronary bypass group				
Group mean (men)	5.1±0.2	5.5±0.2	5.1±0.2	5.3±0.2

*$p < 0.05$ vs. pre-treatment values

By comparison, in the placebo arm the difference between the diagnosis subgroups was 4.4 % during pre-treatment and 4.1 % after the treatment.

The mean group level of the "Mood" parameter in CHF patients increased by 7.7 % following the 3-month taurine treatment, but only 3.8 % in the placebo arm. Mood improvement in the taurine arm was 7.8 % among women ($p < 0.05$) and 5.7 % among men, while it was 3.8 % and 3.9 %, respectively, in the placebo arm (Table 9).

The increase in the "Mood" parameter was 7.8 % among CHF patients in the taurine arm after coronary bypass surgery, but only 3.9 % in the placebo group. The patients with heart valve defects demonstrated a 3.9 % higher value of activity compared to CHD patients, both before and after taurine therapy.

Thus, the general trend of each parameter of WAM-test demonstrates significant improvement. Following taurine treatment, the patients with CHF showed a greater improvement in well-being compared to patients undergoing heart valve surgery without taurine treatment. Moreover, male patients demonstrated a greater improvement in well-being than women. However, the level of activity was higher in female patients. Among the patients with heart valve defects, the activity and mood scores were higher in CHD patients both before and after taurine treatment.

4 Conclusion

1. In patients undergoing heart valve replacement and coronary bypass surgery, the use of taurine resulted in a significant increase in left ventricular ejection fraction and a reduction in left ventricular myocardial mass index and triglyceride levels.

2. Both taurine treatment groups demonstrated a significant improvement in the quality of life.
3. The results of "WAM" testing demonstrated an improvement in Well-being, Activity and Mood in patients enrolled in the taurine arm.

References

Mareev V, Ageev F, Arutynov A et al. (2003) National guideline on the diagnosis and treatment of CHF. J "Serdechnaya Nedostatochnost" 4(6):276–297

Doddakula KK, Neary PM, Wang JH, Sookhai S, O'Donnell A, Aherne T, Bouchier-Hayes DJ, Redmond HP (2010) The antiendotoxin agent taurolidine potentially reduces ischemia/reperfusion injury through its metabolite taurine. Surgery 148(3):567–572

Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA et al. (2006) A report from the American society of echocardiography's guidelines and standards committee and the camber quantification writing group, developed in conjunction with the European association of echocardiography, a branch of the European society of cardiology. Recommendations for chamber quantification. Eur J Echocardiogr 7:79–108

Sahin MA, Yucel O, Guler A, Doganci S, Jahollari A, Cingoz F, Arslan S, Gamsizkan M, Yaman H, Demirkilic U (2011) Is there any cardioprotective role of Taurine during cold ischemic period following global myocardial ischemia? J Cardiothorac Surg 6:31

Suleiman MS, Fernando HC, Dihmis WC, Hutter JA, Chapman RA (1993) A loss of taurine and other amino acids from ventricles of patients undergoing bypass surgery. Br Heart J 69(3): 241–245