Effect of Electrical Stimulation on Femoral Artery Blood Flow in Chronic Heart Failure Patients

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ABSTRACT

Back ground: *Many patients with severe chronic heart failure (CHF) are unable to undertake intensive physical activity. Peripheral muscle are weaker with a decreased mass, low frequency electrical stimulation(LFES) has previously been shown to produce appositive effect on the metabolic functions of skeletal muscle. LFES can be considered a safe and well tolerated method that has no life threatening side effects.* ***Aim of the work:*** *to assess the effect of LFES of quadriceps and calf muscles on femoral artery blood flow in patient with CHF.* ***Methodology:*** *forty patients with CHF were involved in this study, there ages ranged from 40 -60 years with mean age 47.4±5.6 years .patients were divided into two groups, 20 patient for each study and control group, patients in the study received both LFES with frequency five session per week for three successive weeks in addition to medical treatment but patients in control group received only medical treatment.* ***Results:*** *The results of these study revealed statistically significant improvement in femoral artery blood flow in the study group patients in comparison to which of the control group as it was (135.14±23.3 vs 114.08±21.6) and (130±23.4 vs 112.9±20.4) for the right and left femoral artery of the study group, and it was (109.98±18.2 vs 108.31±18.3) and (110.9±18.6 vs 110±18.7) for right and left femoral artery of control group.* ***Conclusion:*** *we concluded that LFES is the best choice for treatment of skeletal muscle disorders in patients with CHF who are unable to undertake intensive in physical activity as conventional exercises.*

INTRODUCTION

Congestive heart failure is a clinical syndrome with a complex pathophysiology initiated by left ventricular dysfunction leading to systemic and pulmonary congestion and elevated peripheral vascular resistance. Fluid retention along with peripheral vasoconstriction and reduced skeletal muscle perfusion provides the pathophysiological basis for the symptoms. Skeletal muscle atrophy, reduced capillary density and reduced cytochrome oxidase activity characterize the condition[1].

Chronic heart failure is often accompanied by complete hypoperfusion, which affects a great part of the skeletal muscle mass. The intensity of catabolism increases, the reactive oxygen species and a large amount of circulating cytokines stimulate the development of apoptosis (apoptosis which is an energy dependent programmed cell death for removal of unwanted individual cells)[4].

Chronic congestive heart failure (CHF) is a complex metabolic syndrome resulting from global hypoperfusion and neurohormonal activation; sympathoadrenergic hyperactivity and stimulation of the rennin-angiotensin aldosterone, which promote endothelial dysfunction in the marco- and microcirculation, and thus influence the distribution of the terminal blood flow[9].

Chronic heart failure is associated with neurohumoral activation and alterations of the peripheral circulation and skeletal muscle. Several mechanisms are involved in the impaired peripheral perfusion, including increased sympathetic tone and increased vascular stiffness. In conductance vessels, flow-dependent dilation is attenuated in patients with chronic heart failure as compared with normal subjects, indicating endothelial dysfunction of large vessels[12].

Heart failure results not only in a fall in cardiac output but also in redistribution of blood flow favouring some regional vascular beds (brain and heart) at the expense of others (kidney and skeletal muscle). This is due to local peripheral vasoconstriction, mediated by increased sympathetic tone and activation of the plasma rennin angiotensin system As consequence of the chronically reduced blood flow, endothelium-mediated vasodilatation is reduced[8].

It is well known that exercise training induces a significant improvement of endothelial functions in patients with CHF and the contractions initiated by local electrical stimulation of the strength muscle may cause similar (or identical) vascular reactions as seen during physical exercises, especially exercise-induced reactive hyperemia in working muscles An acute rise of blood volume increases the shear stress on the vessel wall, which promotes the NO production and liberation[7].

It is possible to suppose that stimulation-induced changes of blood flow velocity are most probably related to the modification of endothelial functions by long-term electrical stimulation, and thus may be NO-dependent. The significant increase of the blood flow velocity in femoral artery during stimulation observed in the study reported by Kojda et al., 2001[6], may reflect the importance of achieved global vascular benefit for the peripheral muscle mass after five weeks of LFES.

Low frequency electrical stimulation (LFES) does not cause any significant change in cardiac output and heart frequency. During the eight weeks of stimulation Wiesinger et al., 2001[14] did not observe any life threatening side effects of LFES on blood pressure or heart rate.

Endothelium dependent vasodilatation (NO) of the peripheral vasculature is impaired in patients with CHF, as a consequence of defective nitric oxide synthase (NOS) activity. The changes in endothelial reactivity and NOS expression seen with sustained increases in blood flow are similar to changes in endothelial behavior in vessels exposed for long periods to intermittent increases in flow by LFES[13].

METHODOLOGY AND PROCEDURES

Subjects

- A group of 40 patients diagnosed with CHF, classified as New York Heart Association (NYHA) classes' III to IV, were included in the study. Their age was ranged 40-60 years. The mean age of the study group was (47.4±5.6 years) and control was (47.5±5.7years). Their mean ejection fraction (EF) was less than 30 %.
- All patients on optimal pharmacological treatment (angiotensin converting enzyme inhibitor (ACEI,) beta blockers diuretics that had remained unchanged for two months before and throughout the study.

Evaluation equipment

Blood flow velocimetry measurement to evaluate changes in peripheral perfusion by pulsed-wave Doppler velocimetry of the femoral artery.

Therapeutic equipment

Low frequency electrical stimulation using an Elpha 2000 dual-channel stimulator to stimulate quadriceps and calf muscles on both lower extremities.

Procedures

Evaluation of blood flow velocimetry,as the standard pulsed-wave Doppler velocimetry of the right and left femoral artery was performed before and after the end of the three weeks period of electrical stimulation.

Low frequency electrical stimulation was performed for one hour/day for five days a week for three consecutive weeks.

Data Analysis

The mean, standard deviation and the range will be calculated for all subjects. Paired "t" test will be used to determine the mean value of blood flow velocity for each subject before and after treatment program and to compare the changes with each group.

RESULTS

This study was included forty patients with chronic heart failure (CHF).Classes III-IV, their ages ranged from 40 to 60 years. Randomly assigned into two groups. Twenty patients for each group. The mean age of the study group was (47.4±5.6 years), while the mean age of the control group was (47.5±5.7 years). Each subject of the study group received both low frequency electrical stimulation with frequency 5 sessions per week for three successive weeks, and medical treatment. Each subject of the control group received only medical treatment.

Table (1) and Fig. (1) show the difference of mean and standard deviation (SD) values of Doppler ultrasound of right femoral artery between the study group and control group before and after the treatment program.

Table (1): Statistical analysis for Doppler ultrasound of right femoral artery before and after the treatment program.

Group / Parameter	Treatment Group	Control Group	t-value	P-value
Before program	114.08±21.6	108.31± 18.4	0.9	P>0.05**
After program	135.14± 23.3	109.9± 18.2	3.7	P<0.05*
P-value	P<0.05 *	P>0.05**		

Level of significance at P<0.05 * = Significant ** = Non-Significant

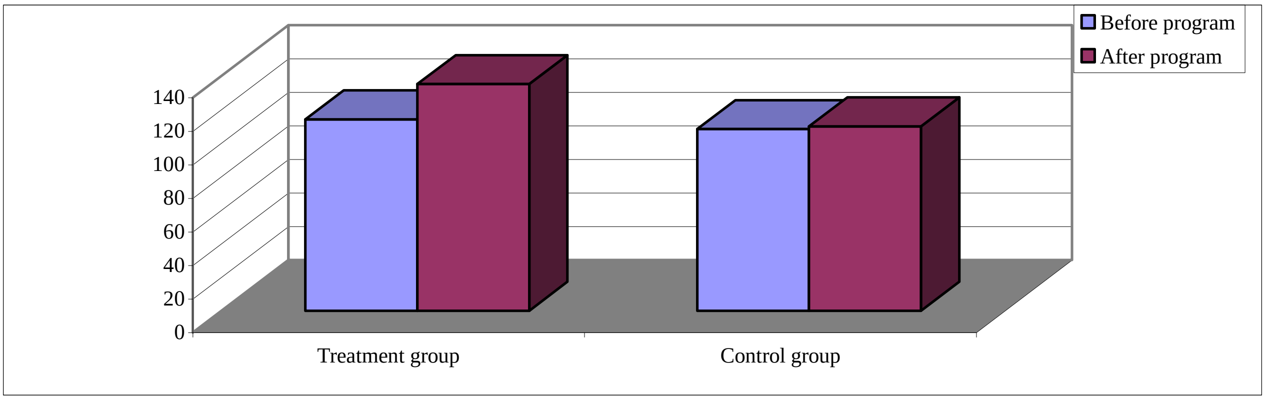

Fig. (1): Statistical analysis for Doppler ultrasound of right femoral artery before and after the treatment program.

Table (2) and Fig. (2) show the difference of mean and standard deviation (SD) values of Doppler ultrasound of Left femoral artery between the study group and control group before and after the treatment program.

Table (2): Statistical analysis for Doppler ultrasound of left femoral artery before and after the treatment program.

Group / Parameter	Treatment Group	Control Group	t-value	P-value
Before program	112.9±20.4	110.05 ± 18.7	0.4	P>0.05**
After program	130.9 ± 23.4	110.8± 18.5	2.9	P<0.05*
P-value	P<0.05 *	P>0.05**		

Level of significance at P<0.05 * = significant ** = nonsignificant.

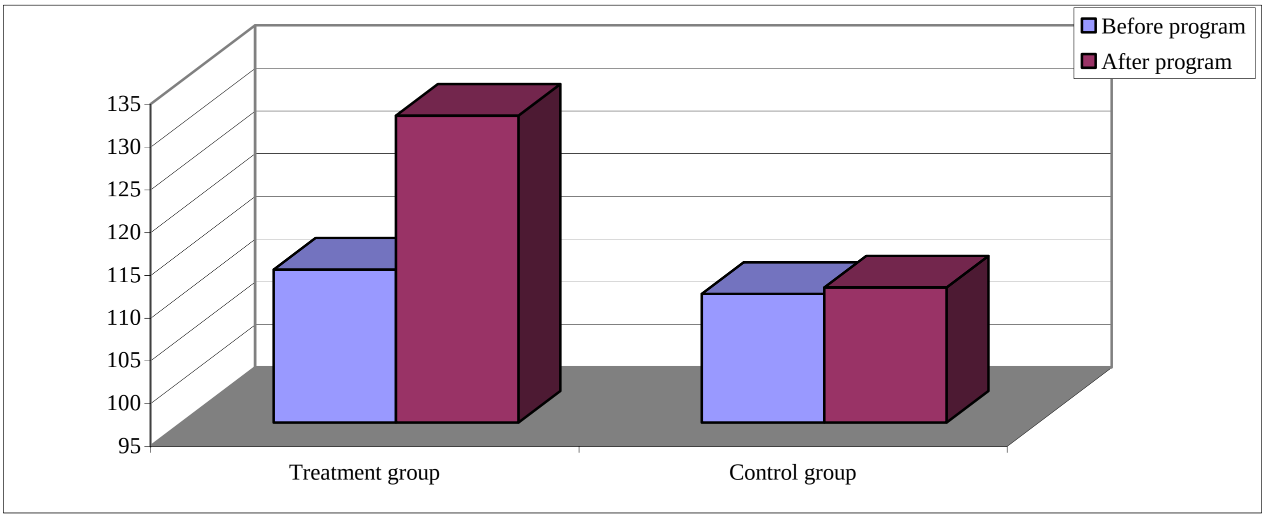

Fig. (2): Statistical analysis for Doppler ultrasound of left femoral artery before and after the treatment program.

DISCUSSION

Functional electrical stimulation (FES) is a method of exercising, which requires less baseline functional capacity to perform. LFES of the lower limb muscles is potentially attractive as a method of training in CHF as it requires less motivation to use, and could be performed by patients unable to undertake conventional training owing to their symptoms of heart failure or other co-morbidities[11].

Our present investigation was designed to investigate whether low frequency electrical stimulation of quadriceps and calf muscles has a beneficial effect on blood flow in patients with chronic heart failure (CHF) or not, with the hypothesis that there may be no effect of low frequency electrical stimulation on blood flow in patient with chronic heart failure (CHF) classes III-IV.

The results in the present investigation revealed statistically significant increase and improvement in blood flow velocity of common femoral artery.

Initial studies showed that , LFES-induced fatigue resistance primarily results from an increase in the capacity of aerobic-oxidative pathways for energy supply, elevated levels of sarcolemmal fuel and metabolite transporters and enhanced capillarization and perfusion[10].

Previous study done by Crevenna et al., 2002[2] who investigate the effects of (LFES) in spinal cord-injuries found improvements of the rates of calcium release, and rates of calcium uptake, and myofilament cross bridge kinetics, after several weeks of LFES training.

Electrical muscle stimulation targets a smaller number of muscle groups. So LFES is well tolerated, safe, although only a crude assessment of central response to local muscle stimulation, it is in keeping with other investigators who have identified no change in cardiac output and only small changes in heart rate during periods of LFES. Whilst this supports the safety of this form of muscle training in CHF patients[11].

The contractions initiated by local electrical stimulation of the strength muscle may cause similar (or identical) vascular reactions as seen during physical exercise, namely the exercise-induced reactive hyperemia in working muscles. Thus, the previously mentioned beneficial effects of LFES on vascular function are most probably related to the effect of increased pulsatile flow on the vessel's endothelial layer. It is likely that the LFES induced changes in blood flow by long-term electrical stimulation are related to modification of endothelial function, and thus may be mostly NO-dependent[5].

These results are very similar to those observed in another study done by Harris et al., 2003[3] who found that, LFES could be regarded as an acceptable analogue of endurance training which can improve the physiological condition of CHF patients in a period of several weeks, and can be easily performed at home without medical supervision.

In our study we selected patients with chronic heart failure (NYHA) classes' III & 1V who are unable to undertake more intensive physical activity and used only LFES because it is safe and well tolerated method has no life-threatening side effects. Results show significant improvement in blood flow and muscle strength.

Conclusion

Low frequency electrical stimulation of quadriceps and calf muscles produced a significant improvement in blood flow in patients with chronic heart failure.

Low frequency electrical stimulation (LFES) can be considered a safe and well tolerated method with no life-threatening side effects. LFES of the lower limbs improve blood perfusion in chronic heart failure.

Low frequency electrical stimulation (LFES) may be used as an alternative to the conventional exercise training and thus provide an opportunity to improve the quality of their lives.

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الملخص العربي

استجابة سريان الدم الشرياني للتنبيه الكهربائي لدي مرضي فشل القلب المزمن

هدف هذه الدراسة هو تحديد استجابة سريان الدم الشرياني للتنبيه الكهربائي لدي مرضي فشل القلب المزمن . أجريت هذه الدراسة على أربعين مريض من مرضى فشل القلب المزمن تتراوح أعمارهم ما بين أربعين إلى ستين عاما و تم تقسيمهم إلى مجموعتين ، المجموعة الأولى (مجموعة الدراسة) التي تلقت للتنبيه الكهربائي للعضلات الهيكلية (العضلة الرباعية وعضله الساق) مع العلاج الدوائي والمجموعة الثانية (المجموعة الضابطة) والتي تلقت العلاج الدوائي فقط . وكانت مدة الدراسة ثلاث أسابيع بمعدل خمس جلسات في الأسبوع ، تم قياس سريان الدم الشرياني قبل بدأ برنامج العلاج وبعد الانتهاء منه . وقد أظهرت النتائج وجود تحسن ملحوظ مع وجود تغيرات ذات دلالة إحصائية في معدل سريان الدم الشرياني لدى المجموعة الأولى التي تلقت للتنبيه الكهربائي مع العلاج الدوائي . وعدم وجود تحسن مع تغيرات ذات دلالة إحصائية في معدل سريان الدم الشرياني لدى المجموعة الثانية التي تلقت العلاج الدوائي فقط ،لذلك يوصى بإضافة للتنبيه الكهربائي للعضلات الهيكلية (العضلة الرباعية وعضله الساق) لعلاج مرضى فشل القلب المزمن .