

# Effect of Enhanced External Counterpulsation on Clinical Symptoms, Quality of Life, 6-Minute Walking Distance, and Echocardiographic Measurements of Left Ventricular Systolic and Diastolic Function After 35 Days of Treatment and at 1-Year Follow Up in 47 Patients With Chronic Refractory Angina Pectoris

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In a prospective study, enhanced external counterpulsation (EECP) was performed for 1 hour each day for 35 days in 47 patients, mean age  $61 \pm 8$  years, with prior coronary revascularization who had chronic refractory angina pectoris despite antianginal drugs and who were not candidates for further coronary revascularization. Compared with baseline values, EECP significantly improved anginal symptoms, dyspnea on exertion, and quality of life after 35 days of treatment ( $P < 0.001$ ) and at 1-year follow up ( $P < 0.001$ ). Compared with the baseline value of  $653 \pm 249$  feet, EECP significantly improved the 6-minute walking distance to  $1025 \pm 234$  feet after 35 days of treatment ( $P < 0.001$ ) and to  $1040 \pm 221$  feet at 1-year follow up ( $P < 0.001$ ). However, EECP did not significantly affect left ventricular ejection fraction, left ventricular end-diastolic and end-systolic dimensions, left ventricular end-diastolic and end-systolic volumes, E/A ratio, isovolumic relaxation time, and deceleration time measured by two-dimensional and Doppler echocardiography.

*Keywords:* enhanced external counterpulsation, angina pectoris, coronary artery disease, left ventricular systolic function, left ventricular diastolic function, echocardiography

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## INTRODUCTION

Enhanced external counterpulsation (EECP) has been demonstrated to improve symptoms and exercise

duration in patients with refractory angina pectoris.<sup>1–4</sup> To the best of our knowledge, the effect of EECP on left ventricular (LV) systolic function and diastolic function has not been previously reported.

This article reports in a prospective study the effect of EECP performed for 1 hour each day for 35 days on symptoms, quality of life, 6-minute walking distance, and LV systolic and diastolic function after 35 days of treatment and at 1-year follow up in 47 patients with prior coronary revascularization who had chronic refractory angina pectoris despite antianginal drugs and who were not candidates for further coronary revascularization.

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## METHODS

A prospective study investigated the effect of EECP performed for 1 hour each day for 35 days on symptoms, quality of life, 6-minute walking distance, and LV systolic and diastolic function after 35 days of treatment and at 1-year follow up in 47 patients with prior coronary revascularization who had chronic refractory angina pectoris despite antianginal drugs and who were not candidates for further coronary revascularization.

The 47 patients included 45 men and 2 women, mean age  $61 \pm 8$  years.

Of 47 patients, 47 (100%) were receiving beta-blockers, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, and long-acting nitrates. Of 47 patients, 10 (21%) were also receiving trimetazidine, seven (15%) nicorandil, and five (11%) diltiazem. There was no change in the doses of these medications during the study.

Measurements were made at baseline, after 35 days of treatment, and at 1-year follow up in 47 of the 47 patients (100%) of 6-minute walking distance, of severity of anginal symptoms on a scale of 1 to 5 with 5 being worst, of severity of dyspnea on exertion on a scale of 1 to 5 with 5 being worst, and of quality of life on a scale of 1 to 5 with 5 being worst. Two-dimensional and Doppler echocardiograms were also obtained at baseline, after 35 days of treatment, and at 1-year follow up to investigate the effect of EEC on LV systolic function by measurements of LV ejection fraction, LV end-diastolic dimension, LV end-systolic dimension, LV end-diastolic volume, and LV end-systolic volume and on LV diastolic function by measurements of E/A ratio, isovolumic relaxation time, and deceleration time.

Student *t* tests were used to measure continuous variables. Chi square analyses were used to measure dichotomous variables.

## RESULTS

Table 1 shows the effect of EECP after 35 days of treatment and at 1-year follow up on severity of

anginal symptoms, severity of dyspnea on exertion, quality of life, and 6-minute walking distance. Table 1 shows that EECP significantly improved severity of anginal symptoms, severity of dyspnea on exertion, quality of life, and 6-minute walking distance after 35 days of treatment ( $P < 0.001$ ) and at 1-year follow up ( $P < 0.001$ ) from baseline values.

Table 2 shows the effect of EECP after 35 days of treatment and at 1-year follow up on LV ejection fraction, LV end-diastolic dimension, LV end-systolic dimension, LV end-diastolic volume, LV end-systolic volume, E/A ratio, isovolumic relaxation time, and deceleration time. EECP caused no significant change in any of these measurements of LV systolic and diastolic function.

## DISCUSSION

EECP is a noninvasive technique in which three pairs of pneumatic cuffs are applied to the calves, lower thighs, and upper thighs and an electrocardiographic trigger is used to sequentially inflate the cuffs, starting at the calves, at the onset of diastole. All the cuffs are deflated simultaneously before the onset of systole. The patient receives this treatment as an outpatient for 1 hour each day for a period of 35 days.

EECP leads to an increase in aortic pressure during diastole. This process of generating a pressure waveform during the counter or reverse phase of normal cardiac pulsation in diastole is called counterpulsation. During systole, the pressure in the cuffs is relieved suddenly. This causes a suction-like effect, which reduces afterload and is called systolic unloading of the LV.

Hemodynamically, EECP augments diastolic blood flow in multiple vascular beds and reduces cardiac afterload. The inflation of the cuffs increases venous return and the diastolic pressure. This increases coronary blood flow.

EECP has been demonstrated to improve symptoms and exercise duration in patients with refractory angina pectoris.<sup>1-4</sup> The effect of EECP on LV systolic function

**Table 1.** Effect of enhanced external counterpulsation on clinical symptoms, quality of life, and 6-minute walking distance after 35 days of treatment and at 1-year follow up after therapy in 47 patients with chronic refractory angina pectoris.

Variable	Baseline	After 35 days	1-year follow up	<i>P</i> value
Anginal symptoms*	$2.7 \pm 0.6$	$1.1 \pm 0.3$	$1.0 \pm 0.3$	<0.001
Dyspnea on exertion*	$2.0 \pm 1.0$	$1.0 \pm 0.5$	$1.2 \pm 0.6$	<0.001
Quality of life*	$3.7 \pm 0.6$	$3.2 \pm 0.5$	$3.2 \pm 0.5$	<0.001
6-minute walking distance (feet)	$653 \pm 249$	$1025 \pm 234$	$1040 \pm 221$	<0.001

All *P* values are <0.001 comparing 1 year with baseline and 35 days with baseline.

\*Severity increases from 1 to 5.

**Table 2.** Effect of enhanced external counterpulsation on two-dimensional and Doppler echocardiographic measurements of left ventricular systolic and diastolic function after 35 days of treatment and at 1-year follow up after therapy in 47 patients with chronic refractory angina pectoris.

Variable	Baseline	After 35 days	1-year follow up	P value
LV ejection fraction (%)	42 ± 8	43 ± 8	42 ± 8	NS
LV end-diastolic dimension (cm)	5.0 ± 0.6	5.0 ± 0.6	5.0 ± 0.6	NS
LV end-systolic dimension (cm)	3.9 ± 0.7	3.9 ± 0.7	3.9 ± 0.7	NS
LV end-diastolic volume (mL)	120 ± 35	121 ± 33	122 ± 34	NS
LV end-systolic volume (mL)	65 ± 19	64 ± 20	67 ± 20	NS
E/A ratio	1.21 ± 0.29	1.22 ± 0.30	1.19 ± 0.31	NS
Isovolumic relaxation time (msec)	91 ± 25	92 ± 24	90 ± 25	NS
Deceleration time (msec)	153 ± 56	158 ± 55	160 ± 60	NS

LV, left ventricular; NS, not significant.

and diastolic function has not been previously reported. EECP treatment reduces arterial stiffness and improves wave reflection characteristics in patients with refractory angina pectoris, reducing LV afterload and myocardial oxygen demand.<sup>5</sup> Patients with coronary artery disease may improve their exercise tolerance after EECP because of improved myocardial perfusion and reduced cardiac workload.<sup>6</sup> Nonspecific placebo effects may also contribute to the observed benefits in symptoms and exercise tolerance.<sup>7,8</sup> EECP causes clinical improvement without electrophysiological remodeling.<sup>9</sup>

The present prospective study also demonstrated that EECP caused a significant improvement in symptoms and in exercise tolerance after 35 days of therapy and at 1-year follow up in 47 patients with refractory angina pectoris who were not candidates for further coronary revascularization. However, EECP did not improve any measurements of LV systolic function or LV diastolic function.

EECP has been approved by the U.S. Food and Drug Administration for the treatment of patients with refractory angina pectoris. The American College of Cardiology/American Heart Association guidelines recommended the use of EECP in patients with chronic stable angina pectoris refractory to medical therapy who were not candidates for coronary revascularization with a class IIb recommendation.<sup>10</sup>

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