Three-Year Sustained Benefit from Enhanced External Counterpulsation in Chronic Angina Pectoris

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Enhanced external counterpulsation (EECP) is a noninvasive method that uses timed, sequential inflation of pressure cuffs on the legs to augment diastolic pressure, decrease left ventricular afterload, and increase venous return.[1,2] Prior studies using a rudimentary form of external counterpulsation have previously demonstrated short-term survival benefits in acute myocardial infarction[3,4] and short-term improvement in the symptoms and ischemic burden of patients with chronic angina,[5] although only minimal changes in systemic hemodynamics and coronary blood flow could be demonstrated.[6] None of these studies assessed the long-term efficacy of this device in treating patients with chronic angina. The purpose of the present study was to evaluate the 3-year efficacy of the enhanced form of this methodology in a previously reported group of patients with chronic angina treated with EECP.[7]

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At entry, the patients had angina despite medical or surgical therapy and reversible perfusion defects demonstrated on symptom-limited thallium stress imaging. Exclusion criteria included aortic insufficiency, clinical congestive heart failure, severe peripheral arterial or venous disease, nonischemic cardiomyopathy, significant ventricular arrhythmias or atrial fibrillation, uncontrolled hypertension (>180/110 mm Hg), recent (<3 months) myocardial infarction, and bleeding diathesis.

Patients received 36 hours of EECP treatment followed by a repeat stress thallium test (to the same duration as the initial one) and a maximal symptom-limited exercise test. Patients were divided into EECP responders (demonstrating improvement in stress myocardial perfusion images after EECP) and nonresponders (unimproved myocardial perfusion after treatment). Cardiac medications were maintained as prescribed by the patient's private physician; aggressive risk factor intervention was not attempted and 8 patients received supplemental EECP during the follow-up period.

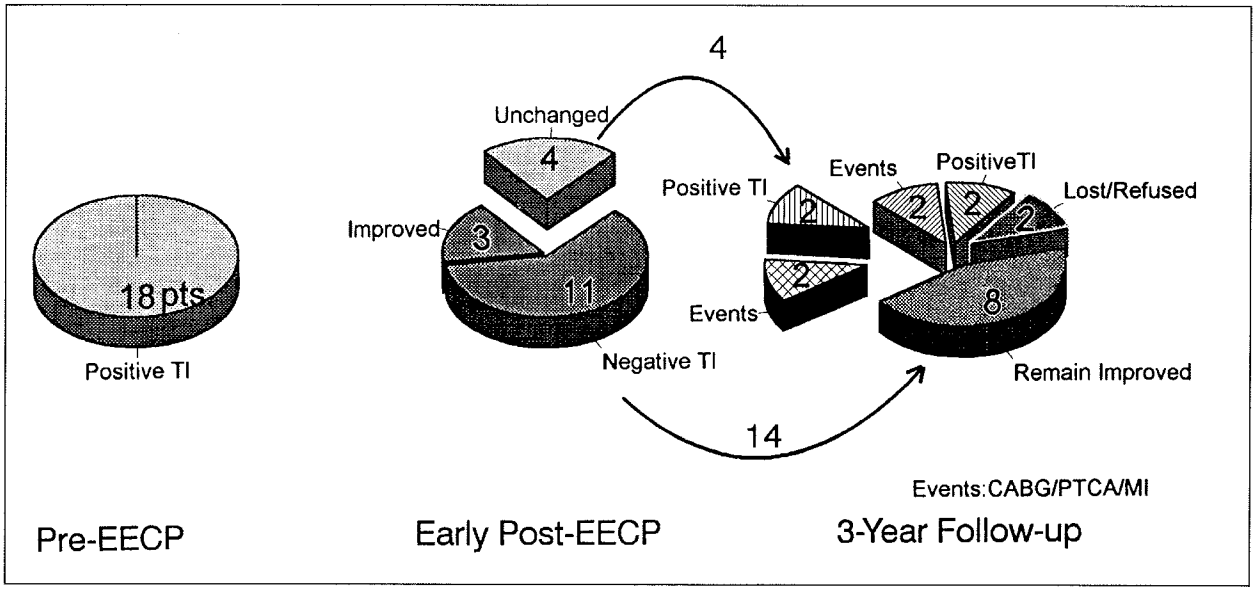

FIGURE 1. Follow-up of 18 patients treated with enhanced external counterpulsation (EECP). *Left,* all patients had thallium (Tl) stress tests showing ischemia (positive tests) before EECP. *Middle,* early (within 1 week) after EECP, 11 patients no longer had evidence of ischemia at the same cardiac workload and 3 had less ischemia (improved thallium test results). *Right,* at 3-year follow-up, of the initial 14 patients who had improvement, results in 8 remained negative, 1 patient was lost to follow-up, 1 refused follow-up stress testing, 2 had reversion to positive stress thallium results, and 2 had events (1 myocardial infarction [MI] and 1 coronary artery bypass graft [CABG]). Of the initial 4 patients who continued to have ischemia before and immediately after EECP, 2 still had positive thallium test results and 2 had events (1 percutaneous transluminal coronary angioplasty [PTCA] and 1 CABG).

Three years after EECP treatment, each patient's clinical status was reassessed. A repeat stress thallium test (again performed to the same duration as the initial study before EECP) was performed on EECP responders who were free of clinical events (myocardial infarction, unstable angina, or revascularization procedures). All nuclear scans were read independently by 2 interpreters unaware of the patient's clinical status.

A statistical analysis was performed using the chi-square test to examine for significant differences between baseline and 3-year follow-up in thallium reperfusion abnormalities and in interim events. Seventeen men and 1 woman (mean age 60 years [range 45 to 75]) participated in the initial study. Before entry, all patients were experiencing angina that severely limited their daily activities despite therapy with combinations of nitrates, β blockers, and calcium antagonists, and 8 patients had previously undergone a revascularization procedure. All patients had a reversible (ischemic) perfusion defect on baseline stress thallium imaging.

As a group, patients had 19 prior attempts at revascularization and 14 prior myocardial infarctions. In the 15 patients having had prior coronary angiography, 4 patients had 3-vessel, 8 had 2-vessel, and 3 had 1-vessel coronary artery disease.

Anginal symptoms improved in all patients early after EECP. Thallium imaging at the same cardiac workload as at baseline (i.e., peak blood pressure and double product were unchanged) revealed improved thallium perfusion (i.e., less or no ischemia) in 14 of 18 (78%) patients, with 4 (22%) showing no objective benefit.[7] Exercise tolerance (exercise to a higher peak heart rate and double product) was also demonstrated to have significantly improved in the group with improved myocardial perfusion.

In the group of 14 EECP responders, 1 patient could not be located, 1 sustained a myocardial infarction, and 1 underwent surgical revascularization in the 3-year follow-up period. The remaining patients continued to be free of limiting angina. In the group of 4 nonresponders, 2 underwent revascularization (1 at angioplasty, 1 at bypass surgery). Thus, a total of 4 patients had interim events in the 3-year period. A summary of the 3-year follow-up results is shown in Figure 1.

One of the initial 14 EECP responders who had been asymptomatic refused 3-year repeat testing. The remaining 10 patients in the early benefit group underwent repeat stress thallium testing at the 3-year mark. Of these 10 patients, 8 continued to demonstrate improved thallium perfusion compared with the baseline study before EECP. However, 2 in the group had reversion to the pre-EECP baseline (i.e., their ischemia worsened from the early post-EECP result despite symptomatic improvement). There were no significant differences in heart rate or double product attained during stress thallium testing at the 3-year follow-up from those noted at baseline and early post-EECP testing. By chi-square testing, improvement in stress thallium perfusion and limiting angina remained highly significant ($p < 0.01$) at 3-year follow-up.

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EECP was previously shown to produce symptom relief and early improved myocardial perfusion in 14 of 18 selected patients (78%) with chronic angina refractory to conventional therapy.[7] Exercise tolerance and indexes of myocardial oxygen demand improved in the group of positive responders. Three-year follow-up in this group of 14 patients who demonstrated early benefit showed that 2 had interim events, 1 was lost to follow-up, and 1 refused stress testing. Follow-up stress thallium testing in the remaining 10 patients who were event-free and had improved thallium test results after EECP showed preservation of early benefit in 8 (80%) and reversion to ischemic baseline in 2 (20%). Thus, of the 17 patients available for follow-up, 10 (59%) were event-free and demonstrated sustained reduction in angina, with most continuing to show improvement in myocardial perfusion.

EECP is postulated to work by facilitating the development, or opening, of coronary collaterals, as has been reported with the use of the intraaortic counterpulsation balloon.[8] As a result, EECP may improve inequalities of regional perfusion, resulting in both subjective and objective improvement in patients with ischemic heart disease.

Both the short-term and now long-term (over a 3-year period) clinical benefits of EECP appear to be maintained in almost all patients treated for chronic disabling angina. That most patients maintained their 3-year benefits suggests that long-term improvement in myocardial perfusion can occur. Future angiographic studies are planned to evaluate collateral function in these patients.

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