REVIEW ARTICLE

Enhanced External Counterpulsation: A New Option for the Cardiac Patients of Bangladesh

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Introduction

Enhanced External Counterpulsation (EECP) is a non-invasive mode of treatment which is given on outpatient basis. This method is used to improve myocardial perfusion and cardiac output, thereby reducing symptoms of angina and heart failure[1] EECP is used to stabilize the coronary circulation in patients with severe coronary artery disease when maximal medical therapy and/or invasive procedures have proven inadequate or exhausted[1]. Improved technology in percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass graft (CABG) has made it possible to successfully treat patients with chronic angina pectoris. However, a large number of patients remain symptomatic in spite of PTCA or CABG, continue to be ineffective or associated with an unacceptable risk of complications. There is an increasingly large population of patients who have persistent residual anginal symptoms and they remain severely restricted physically[2] Following bypass surgery, only 75% of patients are symptom free from ischemic events for 5 years or more, and only 50% remain so after 10 years or more[3] EECP has been shown to be effective in these group of patient[4,5] Complete resolution of ischemic perfusion defects was achieved in 67%, partial reperfusion with decrease in size of defects was noted in 11%, and no change was seen in 22% of patients[5]

History of Counterpulsation

Kantrowitz and Kantrowitz first described the concept of diastolic augmentation as a technique to improve coronary flow in 1953[2] Birtwell and others showed that the ECG QRS complex could be utilized to time an external pumping device that provided a synchronous pulse wave, thereby increasing the development of coronary collaterals[2] Soroff and colleagues described this device could not only produce increased coronary blood flow but also reduce left ventricular work and oxygen demand[6] Soroff, Hui, and Gorlin first coined the term "counterpulsation"[7] Soroff et al first described how application of positive pressure to the lower extremities during diastole could raise diastolic pressures 40%-50% and lower systolic pressures up to 30%[8] Zheng ZS first reported sequential three-cuff external counterpulsation system in 1983[9] In 1995 Food and Drug Administration (FDA), USA approved EECP for use in stable and unstable angina, acute myocardial infarction(MI) and cardiogenic shock, and in 2002 for use in heart failure (HF)[10,11]

How EECP Works

EECP consists of three pneumatic compression cuffs applied to each of the patient's legs. The mechanism is synchronized with the patient's electrocardiogram. The cuffs are sequentially inflated during diastole, in the calves followed by lower thighs followed by upper thighs, resulting in an increase in diastolic blood pressure (diastolic augmentation) and retrograde aortic diastolic blood flow. We know 80% coronary flow access during diastole & only 20% in systole. At the end of diastole, pressure is released simultaneously from all cuffs at a time, resulting in systolic unloading and after load reduction. This sequential compression results in increase venous return and augment diastolic

pressure. The diastolic augmentation increases coronary perfusion pressure and provides afterload reduction and increase venous return with a subsequent increase in cardiac output[12] The degree of hemodynamic effect is monitored by the ratio of systolic to diastolic pressures, which is recorded by finger plethysmography. A usual course of EECP treatment consists of minimum 35 one-hour sessions.

Levenson et al. postulated that an increase in cyclic guanosine monophosphate (cGMP) acutely after EECP therapy might in part be responsible for the improved peripheral arterial function[13] Cyclic guanosine monophosphate regulates vascular smooth muscle tone, which may improve arterial function. Fifty-five subjects were randomized into 2 groups to receive either sham (control) or active EECP therapy for the duration of 1 hour . Plasma and platelet cGMP were measured immediately before and after EECP therapy by radioimmunoassay[13] One hour of EECP therapy increased cGMP plasma concentration by 52% and platelet content by 19%[13] This theory of endothelial stabilization has attracted the most attention in the recent past as one of the primary mechanisms of action, with more clinical trials needed to further understand it completely[13]

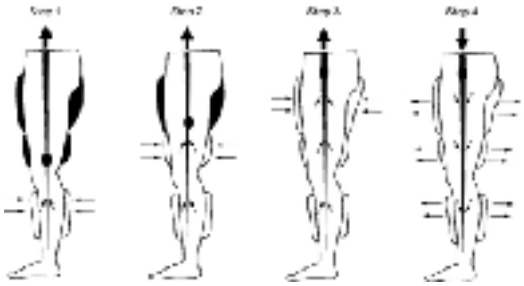

Fig 1: Technique of EECP. Three pairs of pneumatic cuffs are applied to the calves, lower thighs, and upper thighs. The cuffs are inflated sequentially during diastole, distal to proximal and simultaneously deflate all three sets of cuffs at the end of diastole. (Manchanda, A. et al. J Am Coll Cardiol 2007;50:1523-1531).

Fig 2: Patient receiving EECP therapy in a center at Dhaka.

The goals of EECP:[14]

1. Increased Higher Augmented Diastolic Pressure

This increase diastole pressure thus increase coronary blood flow and recruit dormant collateral vessels. Oxygen supply to ischemic myocardium is increased.

2. Lowered Assisted Systolic Pressure

This lowered systolic pressure decreases the oxygen demand of the heart.

3. Lowered End-diastolic Pressure

This lowered pressure at the end of diastole aids in increasing coronary blood flow and decreasing resistance before systole. Oxygen supply is increased and demand is decreased.

4. Increased Venous Return

The cuffs squeezing the lower extremities, increases blood return to the right side of the heart. This increased blood return can increase preload, increase the stretch on the myocardial fibers, and subsequently increase cardiac output.

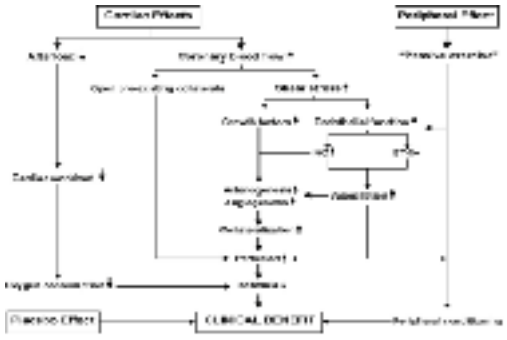

Fig 3: Possible Mechanisms Responsible for the Clinical Benefit Associated With EECP Therapy. (Manchanda, A. et al. J Am Coll Cardiol 2007; 50: 1523-1531).

For Whom EECP is?

EECP therapy is indicated for patients with coronary artery disease who either cannot undergo angioplasty or bypass surgery, or have persistent anginal symptoms following angioplasty or bypass surgery. EECP for use in stable and unstable angina, acute myocardial infarction (MI), cardiogenic shock, and heart failure (HF)[10,11] The EECP therapy was observed to be a safe and effective treatment of angina in patients with severe left ventricular dysfunction (LVD) who were not considered good candidates for revascularization by coronary artery bypass graft or percutaneous coronary intervention[15]

Who should not have EECP?[16]

- Coagulopathy with an INR of prothrombin time 2.5.
- Arrhythmias that may interfere with triggering of EECP system (uncontrolled atrial fibrillation, flutter, and very frequent premature ventricular contractions)
- Within 2 weeks after cardiac catheterization or arterial puncture.
- Decompensated heart failure.
- Moderate to severe aortic insufficiency.
- Severe peripheral arterial disease.
- Severe hypertension 180/110 mm Hg.
- Aortic aneurysm or dissection.
- Pregnancy.
- Venous disease (phlebitis, varicose veins, stasis ulcers, prior or current deep vein thrombosis or pulmonary embolism).
- Severe chronic obstructive pulmonary disease.

Side effects:[16]

- Leg or waist pain.
- Skin abrasion or ecchymoses.
- Bruises in patients using Warfarin when INR dosage is not adjusted.
- Paresthesias.
- Worsening of heart failure in patients with

severe arrhythmias.

Conclusion

Enhanced external counterpulsation offers promise to improve the quality of life for patients with debilitating refractory angina not improved by percutaneous or surgical revascularization. Based on evidence that EECP improves perfusion of previously ischemic myocardium, the alleviation of angina symptoms is related to the development of collaterals, creating a natural bypass. Though EECP has been popular in USA, Europe, China and India earlier but recently it has been used in the management of refractory angina and heart failure world wide. including Bangladesh[17]

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