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Enhanced External Counterpulsation

Theresa Ann Brosche, RN, BSN, CCRN; Susan Kay Middleton, RN; Ronald G. Boogaard, MD, FACC

Ischemic heart disease that is refractory or resistant to medical management is a concern to health team members, patients, and their families. These patients are limited in their abilities to perform activities of daily living and often find it difficult to exercise which negatively affects their quality of life. Some patients are confined to bed rest due to these limitations. Enhanced external counterpulsation (EECP) is a noninvasive outpatient procedure that has been shown to improve the patient's quality of life by decreasing ischemic symptoms and permitting increased activity.

This article reviews the basic principles of EECP therapy and identifies the goals and benefits for the patient. Helpful tips and observations are discussed as to the use of this treatment using evidence-based research. Keywords: Enhanced external counterpulsation, Ischemic heart disease. [Dimens Crit Care Nurs. 2004;23(5):208-214]

Mr Charles Middleton, age 65, arrives at your cardiology office today for a scheduled appointment. He has a history of coronary heart disease and Class 3 angina. (See the Canadian Classification System in Figure 1).*[1] *Mr Middleton states he cannot walk less than one-half a block on a flat surface without experiencing tightness and squeezing across his chest, which is alleviated with rest. He cannot walk stairs without proceeding slowly, and his symptoms worsen as the day progresses. He uses antianginal agents (Imdur 60 mg daily) and (Nitroglycerin SL .6 mg as needed) prior to engaging in activities that may precipitate angina. He is intolerant of both beta blockers due to fatigue and statins due to muscle cramping. He takes an ACE inhibitor (Altace 5mg daily) and also takes an antiplatelet agent (Plavix 75 mg daily).*

His history includes smoking 1 pack of cigarettes per day, which he quit in 1991. He has undergone coronary artery bypass surgery and percutaneous transluminal coronary angioplasty (PTCA) in the past.

Mr Middleton is married; he retired from sales several years ago. He was an active gentleman and enjoyed playing golf, doing yard work, playing with his grandchildren, and coaching youth basketball. Now he is very limited because of his chest pain and can no longer participate in these above activities.

The cardiologist sees Mr Middleton and reviews his history and his limitations from the angina he experiences. Because Mr Middleton is no longer a candidate for further invasive procedures and is not responding to medical management, enhanced external counterpulsation (EECP) is introduced as a treatment option. The cardiologist uses EECP in his office.

*The patient's name has been changed in this article to protect anonymity.

Class 1: Angina with strenuous exercise
Ordinary physical activity, such as walking or climbing stairs, does not cause angina. Angina may occur with strenuous, rapid, or prolonged exertion at work or recreation.

Class 2: Angina with moderate exertion
There is a slight limitation of ordinary activity. Angina may occur with walking or climbing stairs rapidly; walking uphill; walking or stair climbing after meals or in the cold, in the wind, or under emotional stress; or only during the few hours after awakening; when walking more than 2 blocks on level ground; or when climbing more than 1 flight of stairs at a normal pace and in normal conditions.

Class 3: Angina with mild exertion
Marked limitation of ordinary physical activity. Angina may occur after walking one or 2 blocks on level ground or climbing 1 flight of stairs at a normal pace in normal conditions.

Class 4: Angina at any level of physical exertion
There is an inability to perform any physical activity without discomfort. Angina may be present at rest.

Figure 1. Canadian Cardiovascular Society Classification for angina pectoris.

WHAT IS ENHANCED EXTERNAL COUNTERPULSATION?

EECP is a relatively new concept. It is a noninvasive, outpatient procedure designed to relieve angina in those patients whose symptoms are refractory to conventional treatment.[2] EECP has been used to treat refractory angina in Europe for many years. Only recently has it been used for this purpose in the United States. It is similar to the intra-aortic balloon pump (IABP) in that it increases both diastolic augmentation and systolic unloading, thus increasing myocardial oxygen supply and decreasing oxygen demand.[3] EECP has been found to be effective for most patients with refractory angina who do not respond to medical management or who are not candidates for invasive procedures.

EECP is believed to develop and recruit small branches of blood vessels, called collateral circulation, around narrowed or blocked arteries.[4] This creation of a new collateral flow helps increase the supply of blood to the myocardium.

EECP can be used to treat chronic stable angina, but it is usually reserved for patients whose standard medical therapy is losing its effectiveness. It is administered in an outpatient setting, carries little or no risk to the patient, is relatively comfortable and generally well tolerated. The most common side effects are mild headache, mild dizziness, fatigue, and muscle aches. The biggest drawback to EECP is the duration and frequency of treatment. A course of EECP treatment typically involves 35 1-hour sessions at the physician's office, usually 5 days a week over a 7-week period, though treatments twice per day have been effective as well.[5] An estimated 550 sites across the United States use EECP. The majority of these facilities are in cardiologists' offices, approximately 25% are in hospitals, and there is an estimated 40 sites abroad.

Mr Middleton is provided with a video and brochure explaining EECP therapy before leaving the office. He understands the need for continuous treatment that will include 35 1-hour sessions, 5 days per week. He is informed that many patients do not have substantial improvement until after session 15 or 20, and that a small percentage of patients do not obtain desired results from this therapy. Mr Middleton is also informed that EECP is not a substitute for medications and it is unlikely that he will be able to stop taking all, or perhaps any, of his medications. He is made aware that EECP is not a cure, but its use is to improve his quality of life by increasing his ability to carry out activities of daily living and leisure with less angina. He leaves the office to discuss this with his wife and to make a decision as to whether he wishes to proceed with this treatment option.

HOW DOES IT WORK?

EECP involves wrapping the patient's calves, thighs, and buttocks in blood pressure-type cuffs. During diastole, the cuffs inflate sequentially toward the patient's buttocks, beginning at the calves. By compressing the large vessels of the lower extremities during cardiac relaxation, blood flows back to the heart increasing venous return. Patients may describe this sensation as a strong hug moving upward from the calves to the thighs to the buttocks during inflation.[6] At the start of systole, the pneumatic cuffs decompress simultaneously. This decompression acts as a vacuum and decreases the systemic vascular resistance against which the heart pumps. The term "vacuum," while used by many healthcare providers, is somewhat misleading. The blood is actually displaced into the descending aorta due to changes in vascular pressures. Due to the rapid inflation and deflation of the cuffs, the patient's body can appear to be jumping off the bed. Observers and patients often describe this as "jumping and bumping" (Figure 5).

Mrs Middleton had noticed her husband becoming increasingly depressed and withdrawn over the past several years because he was unable to do the activities he once loved. After discussion, they decided to contact the clinical coordinator of the EECP lab at the cardiologist's

office to let her know that Mr Middleton would like to begin treatment. The clinical coordinator answers any questions they may have and prepares them for what will happen during the sessions.

Triggering of Inflation and Deflation

Triggering of inflation and deflation is accomplished using the patient's 3-lead electrocardiogram. The ECG monitors the patient's cardiac cycle throughout the procedure. EECP uses a computerized control unit and software that synchronizes inflation with the cardiac cycle in order to obtain the most favorable therapeutic outcome. Because this system is triggered from the ECG, the EECP therapist continually monitors for phenomena that could affect the waveform, such as artifact, tachycardia, and arrhythmias.

Timing by the Arterial Waveform

A finger sensor, called a plethysmograph, monitors the timing of inflation and deflation of the pneumatic cuffs. The plethysmograph is positioned on a finger of the right or left hand. The patient is asked to keep his or her hand very still and fingers curled in a relaxed position to obtain a stable waveform. The waveform obtained is an arterial waveforms. This waveform provides data for the timing of cuff inflation and deflation.

Viewing the arterial waveform, along with the ECG tracing, allows the EECP therapist to assure that the cuffs are inflating during diastole and deflating prior to systole. This arterial waveform allows the EECP therapist to objectively assess for optimal diastolic augmentation and systolic unloading (Figure 3).

Inflating and Deflating the Cuffs

At the onset of diastole, the cuffs inflate sequentially and increase blood flow back to the heart. This increase in blood flow back to the heart during diastole is called diastolic augmentation and begins after the closure of the aortic valve. The dicrotic notch reflects closure of the aortic valve on the blood pressure waveform. At this point the cuffs will inflate. This diastolic augmentation enhances coronary artery blood flow and increases myocardial oxygen supply (Figure 4).

At the onset of systole, the cuffs are deflated rapidly and simultaneously, reducing systemic vascular resistance. This reduction in systemic vascular resistance decreases myocardial workload and, therefore, myocardial oxygen demand is decreased.

TRAINING FOR THE HEALTHCARE PROVIDER

Cardiovascular technicians, licensed practical nurses (LPNs), medical assistants, and registered nurses (RNs) are among the personnel receiving training to become EECP operators. Training requires operators to have the fundamental skills of basic ECG interpretation, patient assessment skills, basic life support, experience with cardiac patients, and a willingness to learn. A physician, nurse practitioner, physician assistant, or RN will supervise the on-site EECP program and perform detailed patient assessments as needed.

Vasomedical, Inc., the manufacturer of the EECP equipment, provides a 3-day training program for healthcare providers. The program includes the basics of normal heart function, the pathophysiology of myocardial ischemia, the physiology of counterpulsation, and the history of how the current EECP technology and treatment procedure evolved. Training also includes techniques to assure optimal counterpulsation efficacy, with a review of the similarities and differences between EECP and the invasive IABP. The few relative contraindications of EECP therapy are discussed in Figure 2).[3,7]

Mr Middleton arrived for his first EECP therapy session the following week. His concurrent sessions, scheduled by the EECP clinical coordinator, will occur 10:00 AM Monday through Friday for the next 7 weeks. The nurse who will be conducting the treatment session greets Mr Middleton and prepares him to begin the session. There is always a physician, EECP clinical coordinator, nurse practitioner, or physician assistant available as needed during his therapy.

- Abdominal aortic aneurysm requiring surgical repair
- Stent repaired abdominal aortic aneurysm
- Severe edema
- Severe symptomatic peripheral vascular occlusive disease
- Active deep venous thrombosis
- Active phlebitis, severe varicose veins, or stasis ulcers
- Significant coagulopathy (INR 2.0)
- Uncontrolled dysrhythmia that interferes with triggering the EECP timing
- Severe aortic insufficiency
- Severe hypertension (180/110 mm Hg)
- Severe pulmonary hypertension
- Uncontrolled congestive heart failure
- Pregnant women

Figure 2. Contraindications of enhanced external counterpulsation therapy.

CARE OF THE PATIENT DURING TREATMENT

Allay Fears and Anxieties

Reassurance is essential to assure the success of the treatment. The nurse or technician must be cognizant of the patient's needs.

Mr Middleton is apprehensive about the procedure, evident by his elevated heart rate. As the nurse talks with and reassures him, his heart rate resumes a normal sinus rhythm and they proceed with preparation to begin the treatment.

Educate Patient About Taking Medications and NPO Status

Patients are instructed to take all medications as prescribed during therapy. If the patient is diabetic or on dialysis, EECP time may be adjusted around their eating habits, administration of insulin, and their dialysis treatment times. Patient's taking diuretics may be scheduled in the afternoon hours. In addition, patients are asked not to eat or drink anything 1 to 1.5 hours before the treatment.

The nurse asks Mr Middleton if he has taken all of his medication as prescribed, because the patient will need to continue his medication during therapy. She reminds him not to eat or drink anything 1 to 1.5 hours before the treatment. Mr Middleton states he has taken his medications as directed and has not eaten for over 2 hours.

Instruct the Patient to Void Before the Treatment

The upper pneumatic cuffs fit over the patient's abdominal area and, therefore, can compress the bladder. Stopping therapy during a session will not effect the results, however, patients are encouraged to void prior to initiation of the treatment. Patient's may experience a sense of urgency and frequency during therapy. Pyridium may be ordered by the physician for patient's who are voiding 2 or more times during daily treatments. Pyridium is nonopioid analgesic that acts locally on the urinary tract mucosa to produce analgesic or local anesthetic effects.[8]

Provide Extra Padding and Support for the Patient's Bony Prominences

Prior to the application of the treatment, the patient's skin is assessed for skin breakdown or bruising. If the skin is reddened, foam or a synthetic fleece is applied over the area. The padding should not be placed over the bladder of the pneumatic cuffs because augmentation can be affected. If the skin over the calves is bruising, the treatment can be done without the calf cuffs. If the patient develops a contact dermatitis, the physician may order a topical steroid cream.[9]

Skin breakdown—such as open sores, wounds, or blisters—are assessed by the cardiologist overseeing the EECP therapy. He will determine if the treatment session should be withheld until the skin is healed. The patient is also encouraged to keep the area clean and dry.

The nurse applies the pneumatic cuffs to all 4 extremities. When doing the skin assessment the nurse notices that Mr Middleton has a reddened area around his right calf and she places extra padding at the area to protect it from breakdown. The nurse places a support cushion under Mr Middleton's knee, back, and head because Mr Middleton has a history of back and neck pain from an automobile accident several years ago.

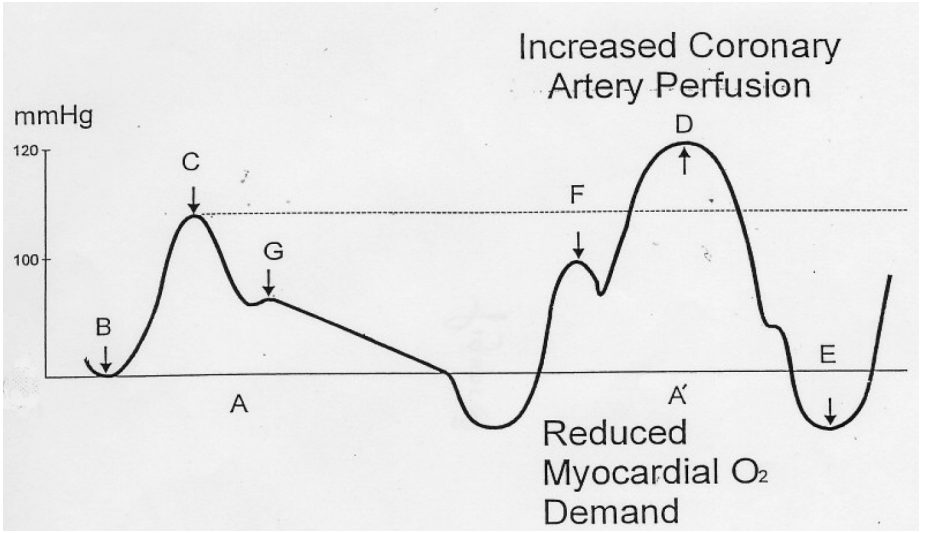

Figure 3. Enhanced external counterpulsation. Key: A, one complete cardiac cycle, without EECP; A′, one complete cardiac cycle, with EECP; B, unassisted end diastolic pressure; C, unassisted systolic pressure; D, diastolic augmentation; E, assisted end diastolic pressure; F, reduced systolic pressure; G, unassisted diastole. EECP is a registered trademark of Vasomedical, Inc. Reprinted with permission.

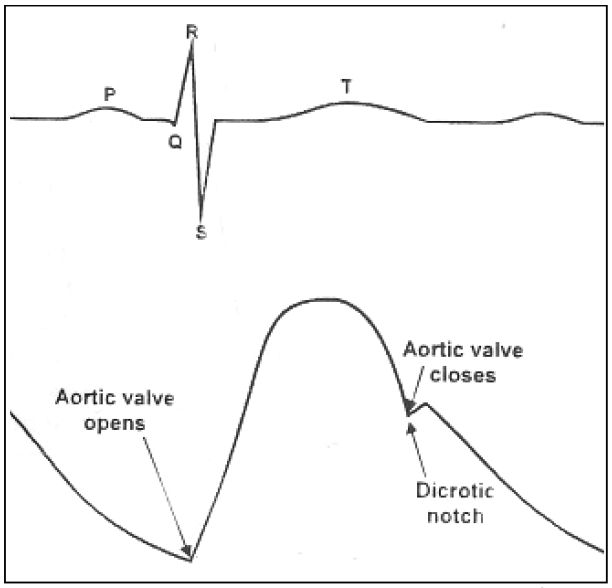

Figure 4. Using the patient's 3-lead electrocardiogram to synchronize cuff inflation and deflation with the cardiac cycle. Courtesy of Vasomedical, Inc. Reprinted with permission.

These measures provide the patient with comfort during his session. The nurse will continue to assure the patient's comfort throughout the treatment.

Assess the Patient Before, During, and After Each Session

The EECP therapist assesses the patient before, during, and after each session. If the oxygen saturation is <90%, if there is a weight gain, a change in vital signs from baseline, or crackles auscultated in the lung fields, the EECP physician is notified prior to treatment initiation. If these symptoms are present before, during, and after the treatment, the physician is notified.

The nurse places the finger probe on Mr Middleton's left hand to assess his oxygen saturation. She listens to his heart and breath sounds. She asks if is comfortable and tells him that treatment will begin. The nurse will continually assess the patient throughout the treatment.

THE GOALS OF EECP

Increased Higher Augmented Diastolic Pressure

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

Lowered Assisted Systolic Pressure

This lowered pressure decreases the oxygen demand of the heart.

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.

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

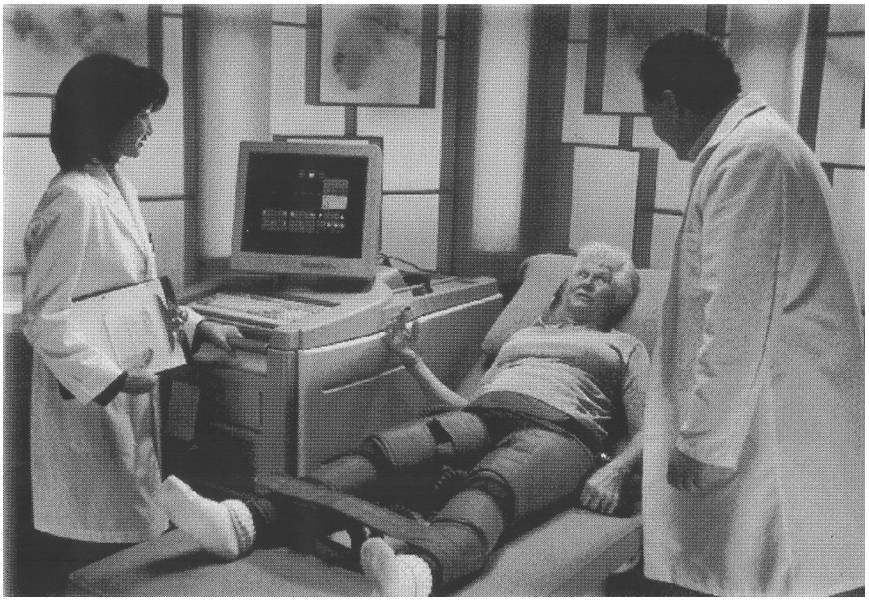

Figure 5. A patient receiving one of the 35 1-hour EECP sessions. Photo courtesy of Vasomedical, Inc. Reprinted with permission.

the stretch on the myocardial fibers, and subsequently increase cardiac output.

BENEFITS OF EECP FOR THE PATIENT

Patients may begin to experience positive effects midway through the 35-week sessions. Each patient experiences relief at different time intervals and with varied symptom relief. Patients and their significant others report less fatigue while conducting activities of daily living such as carrying groceries, mowing the lawn, walking up a flight of stairs, cleaning, bathing, and shaving. They also state they are able to carry out leisure activities, such as golf, swimming, and walking with greater enthusiasm, confidence, and stamina.

The nurse will continually assess the patient throughout the treatment.

Increases in the time to 1-mm ST segment depression with physician-supervised treadmill testing, a decrease in anginal episodes with a trend toward a decrease in nitroglycerin use, and an increase in exercise duration have been found.[10,11] Improvement in levels of depression, anxiety, and reduced somatization, the process by which psychological needs are expressed in physical symptoms, have also been identified.[12]

A 5-year follow up research study revealed, "patients remained alive and without major adverse cardiovascular events and the need for revascularization post EECP treatment".[13] In addition, utilizing the Canadian Cardiovascular Society Classification for angina, patients have been shown to improve their functional class with treatment (see Figure 1). Approximately 75% improve at least 1 functional class and some improve 2 or more.[1]

Brain natriuretic peptide (BNP) is a sensitive measure of cardiac function. Plasma BNP levels increase in heart failure and are mainly secreted from the left ventricle in response to ventricular wall stress or stretch. EECP has been shown to improve left ventricular diastolic filling and decreased plasma BNP.[9]

Mr Middleton completed all 35 sessions. He states that he is now able to walk around his neighborhood without any symptoms of angina. He has been out to the driving range to practice golf and is able to carry a bag of groceries in the house without any symptoms. Mrs Middleton stated that she has noticed her husband to be in much "better spirits." He has improved from a classification of 3 angina to a class 2.

IMPEDIMENTS TO WIDESPREAD USE OF EECP

Evidence-based practice proves the effectiveness of EECP therapy for patients. Medicare has determined that EECP is a cost-effective treatment for patients with Class III or IV angina. Then what is impeding widespread use of EECP? There appears to be several factors.[14] First, many cardiologists do not understand the concepts behind EECP therapy. This is due, in part, to the lack of funding for more research needed to understand and promote the use of the technology. More practice results should be published to educate healthcare providers about this treatment. Second, cardiologists are often more comfortable with a faster treatment, such as open-heart surgery, vascular stents, and percutaneous transluminal coronary angioplasty (PTCA). EECP therapy is not fast, taking up to several weeks to see results. Finally, cardiologists often feel they are failing their patients by not correcting the problem with technology that has more science behind the success. Many physicians are not yet convinced this is an effective treatment regime for their patients, even if they understand and agree with EECP concepts.

CONCLUSION

EECP is a relatively new, outpatient procedure shown to produce positive results for patients refractory to medical management for angina. While it has been available in Europe, it is only beginning to be recognized as an effective treatment for patients with refractory angina in the United States. Ongoing studies are being conducted to assess the effects EECP has for patients with angina, left ventricular dysfunction, peripheral vascular disease, erectile dysfunction, and diabetes. These results are recorded in the *International EECP Patient Registry* (*IEPR*). This registry was established in 1998 to document patient characteristics for those undergoing EECP therapy, the safety and efficacy of EECP therapy, and the therapy's long-term outcomes. Data submitted to the *IEPR* is voluntary and includes approximately 90 contributory sites. The facilities participating in this therapy share information and constantly experiment with new patient care measures to ensure patient comfort along with attaining a therapeutic outcome. An estimated 75% of patients treated with a single course of EECP experience a reduction of angina and are able to return to a more active lifestyle.[14]

An awareness of this cutting-edge therapy will assist the nurse in the exploration and understanding of treatment options used for patients when medical management is ineffective. EECP is another option for patients with angina refractory to other treatments.

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ABOUT THE AUTHORS

Theresa A. Brosche, RN, BSN, CCRN, is a clinical adjunct faculty member, Germanna Community College-Nursing; an Intensive Care Unit Staff Nurse, MediCorp Health Care System; a self-employed legal nurse consultant, and a certified personal trainer.

Susan Kay Middleton, RN, is the Clinical Director, Lebanon Cardiology Associates, PC, Lebanon, Pennsylvania.

Ronald G. Boogaard, MD, FACC, is a Physician at Lebanon Cardiology Associates PC, Lebanon, Pennsylvania.

Address correspondence and reprint requests to Theresa A. Brosche, RN, BSN, CCRN, 1001 Sam Perry Blvd, Fredericksburg, VA 22401 (tbrosche@aol.com).