

Biventricular pacing

When one or two leads aren't enough

According to the American Heart Association, nearly 5 million Americans are currently living with heart failure, with 500,000 new cases expected to be diagnosed each year.

By Rose Czarnecki, RN, BSN, MPM

Heart failure is a complex, progressive disease with many causes. No matter which etiology the disease stems from, once the heart has been damaged, it can no longer maintain the optimal cardiac output necessary to meet the body's metabolic demands.

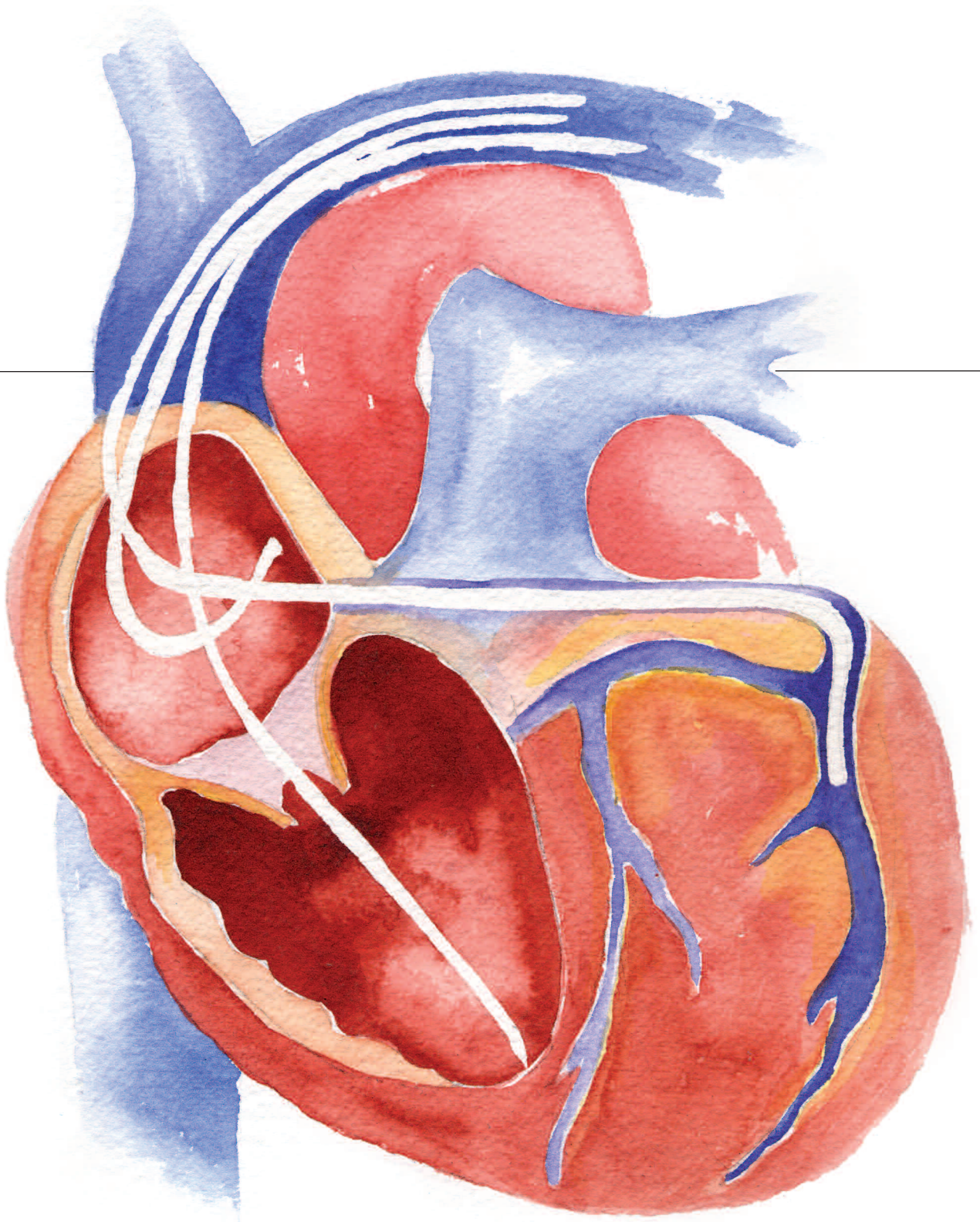
The most common cause of heart failure is left ventricular systolic dysfunction. Systolic heart failure is characterized by left ventricular dilatation and hypertrophy, which result in reduced contractility that leads to decreased function. Impaired left ventricular function causes ventricular conduction abnormalities, which can lead to dysynchrony, atrioventricular conduction abnormalities, diastolic mitral regurgitation, and decreased systolic ventricular filling time.¹

Biventricular pacing, also known as cardiac resynchronization therapy (CRT), is an innovative therapy that can reduce heart failure symptoms

by improving the coordination of ventricular contractions. CRT restores the coordinated pumping action of the ventricles by overcoming the delay in the electrical conduction system and helping the heart work more efficiently without increasing the myocardial oxygen demand. Biventricular pacing aims to ensure coordinated left ventricle contractions (intraventricular contraction) and coordinates contractions of the right and left ventricles (interventricular contraction), as well as providing for optimal atrioventricular synchronization.

Biventricular pacemakers are used to accomplish resynchronization. In addition to the standard two leads (right atrium and right ventricle), this pacemaker uses a third lead to pace the left ventricle. Biventricular pacemakers are manufactured as "stand-alone" devices or with built-in implantable cardioverter defibrillators that can detect

Illustration by Darcy Ferlatto



abnormal rhythms and deliver a shock to convert the rhythm. Patients with heart failure, who have a poor ejection fraction, are at risk for life-threatening arrhythmias and would benefit from these dual devices.

Conduction delays

Patients with systolic heart failure often display significant intraventricular or interventricular conduction delays. Normally, both ventricles contract synchronously with little delay in timing. Interventricular conduction delay occurs when the left ventricle is activated later than the right ventricle. Intraventricular conduction delay occurs when the left ventricle's lateral wall is activated later than the septal wall.¹

An estimated 30% of patients with heart failure have evidence of abnormal interventricular conduction on their 12-lead electrocardiogram (ECG), usually due to left bundle branch block.² This abnormal conduction results in erratic electrical depolarization of the heart with sections of early and late contractions; the right and left ventricle no longer contract in synchrony.

Typically, the interventricular septum contracts early relative to the delayed contraction of the left lateral free wall of the left ventricle. This ventricular dyssynchrony can result in contraction of the septum while the lateral wall is relaxing, or the opposite can occur. Delayed ventricular activation and contraction aren't uncommon in heart failure patients and may contribute to the hemodynamic abnormalities and poor prognosis of systolic heart failure. Up

to 50% of patients with heart failure have abnormal depolarization of the heart.¹

Treatment options

Pharmacologic therapy is still considered the gold standard for treatment of systolic dysfunction. Medications such as diuretics, vasodilators, and positive inotropes are used for the acute treatment of heart failure. Angiotensin-converting enzyme inhibitors, beta-blockers, and aldosterone inhibitors are used in the hopes of delaying the progression of the disease and improving the patient's quality of life.³ For patients who don't respond to optimal pharmacologic therapy with

drome. As recently as a few years ago, medicine offered to heart failure patients few additional therapies other than cardiac transplantation once they'd optimized all pharmacologic options.

Permanent pacing: Limited efficacy

Permanent pacing had long been used to treat heart failure. Patients who experienced symptomatic bradycardia with associated heart block had a permanent atrioventricular pacemaker implanted, with the hope of alleviating their heart failure. However, this therapy failed to produce significant benefits for these patients. These traditional pacemakers



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improved symptoms and cardiac function, newer cardiac devices may be added as a treatment. These patients still experience symptoms with minimal exertion or even at rest (New York Heart Association [NYHA] class III or class IV). (See [New York Heart Association functional classification](#).) This functional limitation often has a discernible effect on their quality of life. The patients may require recurrent and often prolonged hospital admissions for periods of decompensation of their heart failure syn-

use one or two leads to sense and pace the right atrium and right ventricle, creating right atrioventricular synchrony.

Traditional pacemakers don't pace the left ventricle, therefore, they aren't effective in correcting interventricular dyssynchrony. Studies demonstrated that right ventricular pacing didn't produce any hemodynamic benefit and, at times, had negative effects on left ventricular function.²

Improved quality of life

Biventricular pacing is indicated for patients meeting the follow-

Stages of heart failure – ACC/AHA

Classification	Description
Stage A	At risk for development of heart failure; no structural cardiac changes
Stage B	At risk for development of heart failure; structural cardiac changes are present; no signs or symptoms
Stage C	Heart failure symptoms are present
Stage D	Heart failure symptoms are severe; refractory to treatment

New York Heart Association functional classification

Classification	Description
Class I	Minimal or no symptoms with moderate exercise
Class II	Minimal symptoms with light exercise
Class III	Moderate symptoms with light exercise
Class IV	Severe symptoms at rest

ing criteria:

- moderate to severe symptoms of heart failure (NYHA class III and class IV)
- conduction disturbances
- widened QRS greater than 120 ms
- those receiving stable optimum medical therapy
- ejection fraction less than or equal to 35% and in sinus rhythm
- those who aren't likely to improve with additional medications.^{3,4}

Studies have demonstrated that biventricular pacing in patients with moderate to severe heart failure and ventricular dyssynchrony can improve their quality of life, NYHA functional class status, exercise tolerance, and morbidity and mortality.⁵ One of these studies, the Multicenter InSync Randomized Clinical Evaluation (MIRACLE) trial, was the first study that measured therapeutic benefits of CRT in patients with advanced systolic heart failure and ventricular dyssynchrony. The study was designed to measure therapeutic benefits as determined by changes in NYHA

functional classification, distance walked in 6 minutes, and patients' perceptions of improvement in quality of life. This study did demonstrate that a significant portion of patients responded positively to CRT. Sixty-nine percent of patients experienced improvements in their NYHA functional status by one or more class, and 50% demonstrated improvement in exercise capacity, as evidenced by an increase in 6-minute walk distance of 50 meters or greater and improvement in quality of life as measured by the Minnesota Living With Heart Failure Questionnaire.⁶

Use of third lead

In addition to the standard pacing leads that are placed into the right atrium and right ventricle, biventricular pacing includes placement of a third lead in the left ventricle, which takes place through the right atrium and coronary sinus into a left lateral cardiac vein, using an endocardial approach.

Pacing the lateral wall of the left ventricle simultaneously with the right ventricle allows

for both ventricles to contract at the same time, which causes the heart to contract in a more efficient manner, resulting in improved cardiac function.

Preinsertion protocols

The most common technique used to insert a biventricular pacemaker is the endocardial transvenous approach. The procedure is usually done in the cardiac catheterization or electrophysiology lab.

Physicians see most patients prior to the day of the procedure in the preadmission testing department, where they have all their preprocedure lab work and diagnostic testing completed. A venogram may be performed to provide information on the patients' coronary vein anatomy. This information assists physicians in making the correct lead choice and directs positioning that leads properly into the left ventricle.

Patient education and instruction are also completed at this time. Patients are not to receive any food orally after midnight. If ordered by their physician, they may take their medications

the morning of the procedure with sips of water.

Patients are generally admitted through a short stay unit on the morning of the procedure. If not done previously, an admission history and physical are performed along with baseline vital signs. The preprocedure orders are reviewed and any outstanding orders are completed.

Insertion technique

Patients are escorted into the lab and assisted onto the table. Their identification is verified. Nurses start a peripheral intravenous (I.V.) line, usually in the right arm. They also administer an I.V. antibiotic as prophylaxis. Patients are connected to the monitoring system (such as ECG and

blood pressure monitor).

Moderate/procedural I.V. sedation is administered. The left chest area is prepped and draped, and the area is injected with local anesthesia, generally lidocaine.

Once the area is numb, the physician makes an incision and creates a subcutaneous pocket for the insertion of the pacemaker generator. Next, the physician accesses the subclavian vein and threads the distal portion of each of the pacing leads into the right atrium, the right ventricle, and the coronary sinus, guiding them in place under fluoroscopy. After the leads are in place, they're tested to make sure that their placement is correct, that they're sensing

and pacing appropriately, and that the right and left ventricles are synchronized.

Once the physician is satisfied that the leads are in the correct position and working properly, he or she will connect the proximal ends to the pulse generator before placing it into the subcutaneous pocket. The doctor will close the skin and apply a sterile dressing.

Recovery and monitoring

Immediate postprocedure recovery is completed in the lab. The patient's level of consciousness is assessed along with their vital signs to determine if they are stable to move to the inpatient unit. The patient is transferred to a monitored unit where their vital

signs are monitored every 15 minutes for the first hour, every 30 minutes for the second hour, then once every hour for 2 hours. Patients will be placed on a telemetry monitor. Their cardiac rhythm must be closely and continuously monitored. Some physicians may place their patients on a 24-hour holter monitor in addition to the telemetry monitor.

Patients' cardiac rhythm must be observed to identify that the pacemaker is sensing correctly and that it's pacing and capturing appropriately. Look for atrial and ventricular pacing spikes on the rhythm strip. Two ventricular pacing spikes due to right and left ventricular pacing may be seen on the ECG or during pacemaker interrogation. If the pacemaker is failing to sense or pace correctly, it may need to be reprogrammed at the bedside. Patients must also be closely observed for these complications.

Potential complications

Complications that may occur with biventricular pacemaker insertion are similar to those that occur with standard pacemaker implantation, namely:

- pneumothorax
- perforation of the great vessels or the myocardium
- air embolus
- infection
- bleeding
- arrhythmias.

Though rare, some patients may experience perforation of the coronary sinus as a result of the left ventricular pacing lead being inserted through the coronary sinus.

Educate pacemaker patients about electromagnetic interference

Electromagnetic interference can impede the function of the biventricular generator. Patients should be taught what can cause electromagnetic interference so they can avoid exposure.

Some causes are electrical appliances in poor condition or not grounded correctly, or electrical equipment that produces a great deal of energy. It is safe for patients to use most home appliances, office equipment, and certain medical equipment such as chest and dental X-rays, diagnostic ultrasound, computed tomography scan, mammography, and fluoroscopy. Patients with a biventricular pacemaker should avoid sources of magnetic resonance imaging, diathermy, high sources of radiation, electrosurgical cautery, lithotripsy, and radiofrequency ablation.

Transitioning to home

The patient usually remains in the hospital overnight and is discharged the following day. A chest X-ray will be performed prior to the patient's discharge to verify the position of the pacemaker and leads. A final pacemaker check is also completed. The function of the pacemaker and the leads are tested to determine if any changes to the settings are needed before the patient is discharged.

Discharge instructions include wound care, activity guidelines, any changes to their medications, and follow-up care. Patients are instructed to keep the insertion site clean and dry, inspect it daily, and report any signs of infection to their physician.

Activity guidelines are also reviewed. Most physicians allow patients to move their arm normally, but caution against performing extreme pulling or lifting motions. Activities such as golf, tennis, and swimming should be avoided for at least 6 weeks postprocedure. Patients receive a tem-

porary identification card that lists the type of pacemaker and leads, the date of the implant, and the name of the physician who implanted it. Instruct patients to carry this card with them at all times.

Patient compliance

A complete pacemaker check will need to be completed 6 weeks after the procedure, either in the physician's office or at a pacemaker clinic. To obtain the most benefit from CRT, both ventricles should be paced at all times. In addition to the initial pacemaker follow-up, patients will need to be followed regularly to ensure that their pacemaker is functioning properly. Patients must also be taught that CRT isn't meant to replace the other medical therapies prescribed for heart failure. They still need to follow their pharmacologic and nonpharmacologic treatment program.

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tion, electrosurgical cautery, lithotripsy, and radiofrequency ablation. (See **Educate pacemaker patients about electromagnetic interference.**)

Improving symptoms

CRT with biventricular pacing may provide an additional therapy for patients suffering from heart failure. CRT may be safely performed and often results in significant improvement of heart failure with systolic dysfunction. Results from multiple clinical trials have demonstrated symptomatic improvement, restoration of ventricular synchrony, increased exercise tolerance, and improvement in quality of life in these patients. ❖

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