Cardiac pacemakers, implantable cardioverter-defibrillators (ICDs), cardiac resynchronization devices, cardiac physiological monitoring devices, and implantable loop recorders (ILRs) are all categorized as cardiac implantable electronic devices (CIEDs). From their conception, and throughout their technological evolution, they alleviate patient symptoms, reduce mortality rate, and improve quality of life for patients. This symposium is dedicated to topics related to CIEDs. The articles in this series focus on knowledge that nurses in critical care practice should have while caring for patients with these cardiac devices.

The first cardiac pacemaker implantation performed in the United States was in Buffalo, New York, in 1960 by Dr Richard Chardack at the Millard Fillmore Hospital. The engineer who designed and built the first implantable cardiac pacemaker was Wilson Greatbatch. He used $2000 of his own money and a workshop in his garage to develop his idea. His cardiac pacemaker was composed of an electronic board and mercury zinc batteries that were encased in an epoxy shell. It was only capable of pacing the ventricle and was used to relieve Stokes-Adams symptoms of complete heart block. The accompanying epicardial electrode, which was externalized and connected to a freestanding pacemaker, had been placed into the patient weeks earlier. At the time of the implantation procedure, the lead was sterilized, connected to the newly designed implantable cardiac pacemaker, and placed into a pocket created under the skin by a surgeon. The pacemaker was large and not well sealed leading to a short battery life. Greatbatch later transitioned to lithium batteries, which have been used for many years in CIEDs.\cite{1,2}

Cardiac pacemakers today are a fraction of their original size. They are available as single- and dual-chamber models as well as models capable of accommodating a third lead to offer cardiac resynchronization therapy. Cardiac pacemakers are also capable of modulating heart rate response to mimic normal chronotropy with exercise and emotions and automatic switch of pacing mode with sensed atrial fibrillation. Pacemakers automatically minimize ventricular pacing, which has been shown to be potentially detrimental, store information pertinent to managing patient care, including heart failure data, and send information easily by remote technology from the patient’s home to his or her clinician and, additionally certain models allow for exposure to magnetic resonance imaging. Today, several cardiac pacemaker manufacturers are developing future technology, such as leadless and biological pacemakers.\cite{3}

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As cardiac pacemakers were being developed for symptomatic conduction disorders, the concept of the cardioverter-defibrillator was in progress. Peter Zoll invented the external defibrillator during the 1950s. Later, Dr Michel Mirowski, a cardiologist who emigrated from Poland to the United States, invented the idea of making the defibrillator implantable. The first cardioverter-defibrillator implantation procedure was performed in Baltimore, Maryland, in 1980. The original ICD was a large, single-chamber ICD that had limited functionality and no capacity to store memory. It was so large that it had to be implanted in the abdomen. The leads were epicardial patches, and therefore, surgeons implanted the device. The amazing evolution of these devices into the models we have today is extraordinary. They have the ability to provide antitachycardia pacing to overcome ventricular tachyarrhythmias detected in more than 1 rate zone before delivering shock therapy. They discriminate sinus and supraventricular arrhythmias from ventricular arrhythmias, using several different algorithms to reduce the incidence of inappropriate shock. They are smaller with improved battery longevity. Implantable cardioverter-defibrillators offer the additional option of providing fully functional single, dual, and cardiac resynchronization pacing therapies with memory storage and remote monitoring capabilities that cardiac pacemaker technology offers.4 Newer advances have led to the development of the subcutaneous ICD (SICD) with a lead that is placed under the skin rather than transvenously. The SICD has been developed to allow patients with limited venous access or at a greater risk for infection to have the protective benefit of an ICD.6

Cardiac resynchronization therapy in patients with dyssynchrony, specifically from left bundle branch block, coordinates ventricular electrical activation from either the right to left or left to right ventricle, as well as from the atria to ventricles by using 3 leads: one is placed in the right atrium, one in the right ventricle, and one in a posterior lateral tributary of the great cardiac vein accessed via the coronary sinus. Cardiac resynchronization therapy allows for a more physiologically normal ventricular activation pattern that results in more efficient cardiac functionality. Cardiac resynchronization therapy, whether provided as a pacemaker or in combination with an ICD, has been shown to improve patients’ quality of life and increase exercise tolerance.6

Implantable diagnostic devices to identify cardiac arrhythmias, conduction disease, and heart failure progression have been developed more recently. The ILR is a tiny device, the size of a wooden matchstick that is easily inserted under the skin in the left chest area. The ILR offers remote monitoring to easily and promptly determine the etiology of syncope and palpitations caused by arrhythmias such as atrial fibrillation. With mobile technology, ILR patient information is transmitted to a secure website for the physician to receive data almost immediately. Implantable loop recorders offer a promising opportunity to reduce complications associated with atrial fibrillation by early diagnosis.7 The implantable devices dedicated solely to measuring pulmonary artery pressures in patients with heart failure have augmented heart failure information offered by other CIEDs. These devices are new to the field. They have similar remote monitoring capabilities as the other CIEDs. Although these devices are not described in this series of articles, both are available CIEDs to be followed.

This series for AACN Advanced Critical Care will provide knowledge clinicians should have when caring for patients with CIEDs. Each of the contributing authors is an expert in his or her practice. One article provides the reader with an explanation of the implantation procedure, including potential complications that may occur and should be observed for. Some long-term complications lead to the need for the CIED to be extracted. Conditions that lead to an extraction procedure and the significant risks associated with that procedure are discussed. Cardiac resynchronization therapy has improved the lives of patients with heart failure. However, benefit has been demonstrated only in approximately two-thirds of those who have received these devices.8 Maximizing benefit can be a challenge. One of the articles in this series reviews techniques to achieve optimized resynchronization therapy. Remote monitoring has revolutionized our ability to follow and troubleshoot issues with CIEDs. A discussion on the benefits of this technology is presented here. Finally, what happens to patients with CIEDs at the end of life? Nurses in clinical practice are dealing with patients with CIEDs who will be faced with difficult decisions such as when to discontinue device therapy, both defibrillation and pacing. The ethical and practical components of these choices are presented in the final article of this series.

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Technology in the field of CIEDs is rapidly growing, as are indications for implantation in current practice. To ensure good clinical outcomes for patients with CIEDs, nurses as part of the health care team dealing with patients suffering from cardiac disease, must acquire the knowledge to provide good, evidence-based practice, including the management of CIEDs. This series enhances the learning process.

REFERENCES