

<b>Title</b>	Pacemaker Update
<b>Authored By</b>	Janet Mahoney PhD RN, CNS-C, CEN, CNA
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## Purpose

The goal of this course is to provide the reader with information and resources related to cardiac pacemakers.

## Objectives

1. List two reasons patients receive pacemakers.
  2. Discuss differences between various types of pacemakers.
  3. Describe situations in which people with pacemakers need to take special precautions.
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What do Vice President Dick Cheney and Elton John have in common with an estimated 2,000,000 people worldwide? A heart condition requiring the aid of a cardiac pacemaker (www.pbs, 2001; www.Mdb 1999). An estimated 600,000 people receive pacemakers every year, primarily to treat bradycardia (slow heart rate). Although, young and old alike, benefit from pacemakers, the aging population have a particular vulnerability. Elderly clients are at increased risk for dysrhythmias because of changes in their cardiac conduction system. The sinoatrial node has fewer pacemaker cells. There is loss of fibers in the bundle branch system. Therefore, elderly clients are at risk for sinus node dysfunctions and may require pacemaker therapy (Matteson & McConnell, 1988).

Pacemakers have become a reliable means of improving a person's quality of life and in helping people live longer. The public relies on nurses to provide them with accurate information, so it is important for nurses to keep abreast of the newest technological advances in this area.

## Brief History of Pacemakers

Beginning in the eighteenth century, physicians realized that electrical stimulation causes the heart to contract. Although there is some discrepancy as to who invented the first pacemaker, there is a hand full of people noted for their work in pacemaker technology. In 1889, McWilliam applied an electrical impulse to the human heart in asystole which caused a ventricular contraction (McWilliam, 1889).

In the nineteen thirties, Dr. Albert Hyman invented and patented an "artificial pacemaker." This pacemaker was used for emergency resuscitation in the operating room. Later, Dr. Paul Zoll developed a combined electrocardiograph and pulse stimulator to jump-start the heart when the heartbeat did not occur naturally. Dr. Zoll's invention was manufactured by Electrodyne as the PM-65 and was presented to the medical community in 1955. This machine was the size of a large microwave and a cart with an extension cord was needed for patients to get around. It was primarily intended for emergency life-support during cardiac surgery (Artificial Pacemaker, Wikipedia, 2008).

In 1957, Dr. Walton Lillehei pioneered open-heart surgery at the University of Minnesota where he used the PM-65. The pacemaker was used to keep the heart beating until the patient's own heart was able to beat again by itself. When a power failure caused the line-powered pacemaker (PM-65) maintaining one of Dr. Lillehei's patients failed, Dr. Lillehei requested the help of Earl Bakken to "make a pacemaker that could run on batteries."

It became the first wearable external pacemaker. Hence, Bakken delivered a prototype of a battery powered pacemaker late in 1957, which was first used on patients in 1958. This prototype gave rise to the 5800-series of Medtronic pacemakers. Bakken's battery-powered pacemaker was dramatically smaller and weighed less than anything else on the market at that time. One of the first in a line of 5800 series pacemakers it resembled a transistor radio with metal handles on the sides, two dials in the center, and two large bolts on top. This was a huge improvement to the line-powered microwave size pacemaker (Artificial Pacemaker, Wikipedia, 2008).

During the same time span, Rune Elmqvist developed the first implantable pacemaker at the suggestion of Dr. Ake Senning, a surgeon at the Karolinska Institute in Stockholm, in 1958. This pacemaker ran at a constant rate of 70 – 80 impulses a minute. The first implant took place on October 8, 1958. The patient was Arne Larsson, who is reported to be alive and well, after a dozen or so pacemaker modifications. Since that time, there have been many technological advances in the pacemaker industry (Artificial Pacemaker, Wikipedia, 2008).

## **Why a pacemaker?**

Pacemakers are commonly used for the correction of conduction disorders that are not temporary, including complete heart block and sick sinus syndrome. In general, pacemakers are implanted either to alleviate symptoms caused by bradycardia or to prevent severe symptoms in patients who are likely to develop symptomatic bradycardia. The term "symptomatic bradycardia" is defined as a documented bradyarrhythmia that is directly responsible for the development of syncope or near-syncope, transient dizziness or light-headedness, and confusional states resulting from cerebral hypo-perfusion attributable to slow heart rate. Fatigue, exercise intolerance, syncope and congestive heart failure may also result from bradycardia (ACC/AHA/NASPE Practice Guideline, 2002).

What happens in a bradycardia is that the cells in the sinoatrial (SA) node and atrioventricular (AV) node no longer send messages to the myocardium or the messages may be blocked somewhere in the electrical pathway. Either way, messages cannot get to the necessary portions of the heart muscle to make it contract.

If the bradycardia is sustained, such as in patients with a complete AV block, an electrocardiogram can diagnose the condition, indicating the need for a pacemaker. If the bradycardia is intermittent, a 24 hours Holter monitor, a continuous loop recorder, or an electro-physiology test may be needed to document a relationship between the symptoms and bradycardia (Ignatavicius, & Workman, 1995).

## **Complications of pacemakers.**

Severe complications are rare. Early surgical complications may include: pneumothorax, perforation of the atrium or ventricle, hematoma, infection, wound dehiscence and brachial plexus injury. Other early complications include: lead dislodgement, loose setscrew, high thresholds, diaphragmatic stimulation, and pacemaker syndrome. Pacemaker syndrome is a constellation of signs and symptoms representing adverse reaction to VVI pacing (Alexander, Schlant, & Fuster, 1998). Late complications include: high thresholds, lead failure, pacemaker failure, loose setscrew, diaphragmatic stimulation, infection, skin erosion, battery depletion,

venous thrombosis, pacemaker syndrome, and pain (Alexander, Schlant, & Fuster, 1998).

Patients should immediately report the following symptoms to their physician.

- Signs of infection at the incision site – redness, warmth, tenderness,
- Swelling, drainage or fever
- Edema of the arms, legs, wrists or ankles
- Shortness of breath or chest pain
- Weakness, fatigue, fainting, palpitations or muscle twitches

([www://http.yourttotalhealth.ivillage.com](http://www.yourttotalhealth.ivillage.com))

In October of 2007 Medtronic announced a recall of its Sprint Fidelis Defibrillator leads after numerous reports of device failures leading to serious injuries and at least five deaths (Medtronic Recall, 2007). Patients with Medtronic defibrillators should refer to their Patient ID card to determine whether the leads for their device are affected by the recall. The recall includes the following models: Model 6930, Model 6931, Model 6948, and Model 6949. For questions about the recall call toll free 1-800-883-8888.

## **Types of Pacemakers**

Pacemakers have changed over the years. The newer models have fewer problems associated with them. Pacemakers consist of a pulse generator with battery and circuitry providing electrical energy and timing, a pacing lead (an insulated wire that carries electrical impulses to the heart and information about the heart's natural activity back to the pulse generator) and one or two leads depending on the type of pacemaker prescribed ([www://http.medtronic.com](http://www.medtronic.com)).

There are single lead pacemakers and dual chamber pacemakers. Single lead pacemakers are used primarily in situations that are treatable with one lead. When the problem with a slow rate occurs only occasionally and for relatively brief periods of time, a single lead in the ventricle may be all that is needed to provide pacing at those times.

When the only problem is with the formation of the initial impulse in the atrium, placing a lead in the right atrium will "initiate a beat" when it is needed and the electrical impulse will then continue normally through the rest of the atrium, the AV node and the ventricles. In other situations, the patient may have chronic atrial fibrillation with the ventricle pacing at a slower rate. In this case, a single lead placed in the ventricle will control the rhythm. The pacemaker lead cannot be placed in a quivering atrium because it cannot be paced.

Dual chamber devices are used to keep the upper and lower chambers contracting in proper sequence. Dual chamber pacemakers typically use two pacing leads, one placed in the right atrium and the second placed in the right ventricle; the electrical pulses delivered to the heart are timed so that the atria and ventricles beat in synchronization.

The earliest pacemakers did not sense if the heart was making any impulses on their own. They were described as "fixed rate" pacemakers and are no longer manufactured. Current devices are described as "demand" models. The demand type paces the heart only when needed and in response to a person's activity. Rate responsive pacemakers use a special sensor to recognize body changes and adjust the patient's heart rate to speed up or slow down as needed. The most appropriate pacing mode must always be determined on an individualized basis.

## **How do pacemakers work in the body?**

Usually the insertion of a pacemaker is considered minor surgery. In most cases, only sedation is used. A local anesthetic is used to numb the area over where the pulse generator will be placed. An incision of 3 inches by 2 inches in size and less than one half of an inch in thickness is made. A pocket is formed overlying the muscle on the chest wall (<http://www.heartpoint.com>). The surgical site will usually be uncomfortable for one to two weeks. Analgesics such as aspirin, acetaminophen, or ibuprofen can be used, if not contraindicated.

Pacemaker leads usually are bipolar, with the distal electrode serving as the cathode. Bipolar leads have one electrode at the tip of the lead and another about 1 cm proximally. Bipolar leads produce tiny spikes on the EKG, which can be easily overlooked.

Unipolar leads are less commonly used because of the potential for pacing chest wall muscles. They have one electrode at the tip and the pacemaker box serves as the other electrode. The pacemaker spikes are very tall and obvious. The leads are inserted into the heart either percutaneously through a subclavian vein or by cutdown into a cephalic vein. Atrial leads are positioned in the right atrial appendage and ventricular leads are placed in the right ventricular apex (<http://www.heartpoint.com>).

There are two major types of leads. The tined lead, which uses the small plastic tine, it adheres itself passively to the muscle in either the atrium or ventricle. The screw-in type lead is screwed into the muscle of either the atrium or ventricle (<http://www.heartpoint.com>).

## Universal Pacemaker Code

In 1974, the Inter-Society Commission for Heart Disease established a three-position pacemaker code (ICHD Code) to standardize the description of pacemaker systems (Underhill et al., 1989). Today, the mode of pacing is described in shorthand by using the universal code consisting of three to five letters (Ferry, 2001).

The first letter indicates the chamber or chambers paced, that is, the chamber containing the pacing electrode. The chamber paced can be the atrium (A), the ventricle (V), or dual, the atrium and ventricle (A-V) or (O) for none.

The second letter indicates the chamber(s) sensed. Chambers sensed can be the atrium (A), the ventricle (V), dual atrium and ventricle (A-V) or none (O). Information sensed is sent to the generator for interpretation and action by the generator.

The third letter indicates the pacemaker activity or mode of response. (O) indicates no response to the electrical activity sensed; (I), inhibition of the pacing action; (T), triggering of the pacemaker function; and (D), that a dual response of spontaneous atrial and ventricular activity will inhibit atrial and ventricular pacing. Inhibitory response means that the response of the pacemaker is controlled by the activity of the patient's own heart; that is, the pacemaker will not function when the patient's heart beats. In contrast, triggered response means that the pacemaker will trigger a response based on intrinsic heart activity.

The fourth letter, previously used to describe programmable functions, is now used to designate variability of the pace rate with metabolic need. Responses may be simple programmable (P), multiprogrammable (M), communicating (C), rate modulation (R) or none (O).

The fifth and last letter relates to antitachycardia functions. These are represented by pacing (P), shock (S), dual (pacing and shock) (D), and none (O). This type is more usually incorporated into automatic implantable defibrillators (Ferry, 2001).

Using the pacemaker coding nomenclature, the earlier pacemaker of the 1950s may have been classified as a V00. This means the chamber paced was the ventricle (V), there was no sensing built into these early types, so the chamber sensed was (O) and the activity was neither triggered nor inhibited, so the code of (O) is indicated. There were many problems associated with the earlier types of pacemakers. The problems included: "R on T" phenomenon, the battery being used constantly, distortion of all QRS complexes, no AV synchrony, and no rate responsiveness (Ferry, 2001).

Second generation pacemakers paced in the ventricles, sensed in the ventricle and were triggered (VVT). This type solved the potential problem of ventricular arrhythmia by avoiding firing on the upslope of the T wave, but still had all the previous problems associated with the VOO type (Ferry, 2001).

The third generation pacemaker, the VVI, paced the ventricle, sensed in the ventricle and was inhibited. The basic rate was programmable. This type fired only if a ventricular beat did not occur during the programmed timing cycle. This technology decreased battery utilization, deformation of every QRS complex, and "R on T" phenomenon.

Fourth generation pacemakers pace and sense in the atrium and ventricle and could be programmed to be inhibited or triggered. They were named "DDD" which stands for Dual, Dual, Dual. The ventricular rate and the AV delay were programmable. (Ferry, 2001). Problems associated with DDD mode was that there is no rate responsiveness. The typical setting for this type of pacemaker is DDI, which means that the pacing functions are inhibited by appropriate atrial and ventricular depolarization (Ferry, 2001).

Fifth generation pacemakers have the ability to detect increasing physical activity by the patient, usually by sensing pectoral muscle artifact. These pacemakers can increase the heart rate according to programmed parameters. Both VVI and DDD pacemakers can utilize this technology. The DDDR mode pacemaker solves the problems of "R on T" phenomenon, constant use of the battery, distortion of all QRS complexes, no AV synchrony, and no rate responsiveness (Ferry, 2001).

## **Patient Education**

Patient education is essential. There are many myths that should be addressed before sending patients home with their new pacemaker. The following are general patient education materials that will increase patients' understanding about pacemakers. Always keep in mind, that patients should discuss concerns with their physician.

When a patient goes home it is important for them to follow the instructions for pacemakers site skin care and to report signs of infections. Sign of infection include: fever, redness, swelling or drainage from the incision site. Follow instructions on restrictions on physical activity, such as no sudden, jerky movement for eight weeks to allow the pacemaker to settle in place.

Patients should not play with the insertion cite. "Twiddler's syndrome" is a term applied to patients who intentionally or unintentionally manipulate their pulse generator, causing twisting of the entire pacemaker system. This may lead to dislodgment or fracture. This may also result from an excessively large pacemaker pocket allowing rotation of the pacemaker (Alexander, Schlant, & Fuster, 1998). Avoid causing pressure over the area of your chest where your pacemaker's generator was put in. Women may want to wear a small pad over the incision as protection from their bra strap.

The manufacturer's instructions suggest that patients check their pulse; some physicians say it confuses patients. For example, a common question that many patients ask their physician is

“Why is it that the pacemaker is set for 70 beats per minute and when checking their pulse they get 64 beats per minute? Patients may think that their pacemaker is broken. The problem stems from the fact that the patient’s pulse is the expression of the mechanical contraction. The pacemaker does not care about contraction, though – it is an electrical device. There are many circumstances where an electrical event occurs, such as a premature beat that results in the pacemaker sensing the event and resetting its timers. The premature beat does not result however in sufficient cardiac output for the patient to register a pulse. The pacemaker will correctly sense all of the beats, and pace at all the right times, yet results in a lower-than-programmed pulse rate. More important, it is essential for patients to check their pulse when they feel symptoms of a possible failure. Heart rate and symptoms should be reported to their physician. Notify the physician for any of the following: difficulty breathing, dizziness, fainting, prolonged weakness or fatigue, swelling of arms or legs, chest pain, weight gain and prolonged hiccapping ([www.yourttotalhealthvillage.com](http://www.yourttotalhealthvillage.com)).

Patients need to inform all of their physicians and dentists about their pacemaker. Dental equipment does not appear to affect pacemakers adversely although some patients may feel an increase in pacing rates during dental drilling. Modern pacemakers have built-in features to protect them from most types of interference produced by other electrical devices. Also, patients with pacemakers should carry an identification card and wear a medical alert (Medic-Alert) bracelet. ID cards are available through the American Heart Association.

Magnetic resonance imaging (MRI) uses a powerful magnet to produce images of internal organs and functions. Metal objects are attracted to the magnet and are normally not allowed near MRI machines. The magnet can interrupt the pacing and inhibit the output of pacemakers. If an MRI must be done, the pacemaker output in some models can be reprogrammed. Researchers are experimenting with technologies that will allow patients with pacemakers and other implanted devices to have an MRI. Scientists are examining potential methods of shielding the pacemaker during an MRI and creating wireless devices that would not be affected by the MRI’s magnetic fields. Such devices might temporarily take over some or all of the pacemaker’s functions while the pacemaker is turned off for the MRI test. Patients should always discuss with their doctor the possible risks and benefits before undergoing an MRI scan (Roguin A, Zviman M, Meiningner G, et al. (2004).

Diagnostic radiation (such as screening x-ray) appears to have no effect on pacemaker pulse generators. However, therapeutic radiation (such as for treating cancerous tumors) may damage the circuits of the pacemaker. The degree of damage is unpredictable and may vary with different systems. But the risk is significant and builds up as the radiation increases. The American Health Association recommends that the pacemaker be shielded as much as possible, and moved if it lies directly in the radiation field. If a patient depends on their pacemaker for normal beat pacing, the electrocardiogram should be monitored during the treatment and the pulse generator should be tested after and between radiation sessions.

Transcutaneous electrical nerve stimulation (TENS) is used to relieve acute or chronic pain. Several electrodes are place on the skin and connected to a pulse generator. Most studies have shown that TENS rarely inhibits bipolar pacing. It may sometimes briefly inhibit unipolar pacing. Reprogramming the pulse generator can rectify this.

Extra corporeal shock-wave lithotripsy (ESWL) is a noninvasive treatment that uses hydraulic shocks to dissolve kidney stones. This procedure may be done safely in most pacemaker patients, with some reprogramming of the pacing. Patients need careful follow up after the procedure and for several months to be sure the unit is working properly. Patients with certain kinds of pacemakers implanted in the abdomen should avoid ESWL.

Electroconvulsive therapy appears to be safely used in-patient with pacemakers. Usually there

is no rate increase, total inhibition, or damage to pacemaker (Alexander, Schlant, & Fuster (1998).

Patients with pacemakers should not lean over electric or gasoline engines or motors. Be sure that electric appliances or motors are properly grounded. Stay away from any arc welding equipment. Arc welding can create a high-energy field that will reprogram pacemakers. Power generating equipment and powerful magnets (as in medical devices, heavy equipment or motors) can inhibit pulse generators. Patients who work with or near such equipment should know that their pacemakers might not work properly in those conditions.

When going on trips, inform airport personnel of your pacemaker before passing through a metal detector and show them your pacemaker identification card. The metal in the pacemaker will trigger the alarm in the metal detector device.

Cell phones available in the United States do not appear to damage pulse generators or affect how the pacemaker works because the cell phones usually work on less than 3 watts. As the Federal Communications Commission (FCC) makes new frequencies available, cell phones using the new frequencies might make pacemakers less reliable. Cell phone companies are studying this possibility. Recently published studies performed on patients at the Mayo Clinic in Rochester, Minnesota and at the Mount Sinai Medical Center in Miami Beach, Florida, as well as laboratory studies in the U. S. and Canada, have shown that when some cellular phones are placed very close to implanted cardiac pacemakers, interference with the pacemaker's normal delivery of pulses can occur. Although FDA is not aware of any actual incidents in which cellular phones have caused people's pacemakers to malfunction, the agency is concerned about this possibility, and is conducting its own laboratory studies. So far, FDA's results agree with those of the preliminary studies. The type of interference under study is called "electromagnetic interference" or "EMI." If it were to occur, it could affect the pacemaker in one of three ways: by stopping the pacemaker from delivering the stimulating pulses that regulate the heart's rhythm; by causing the pacemaker to deliver the pulses irregularly; or by causing the pacemaker to ignore the heart's own rhythm and deliver pulses at a fixed rate (cellular phone interference - <http://www.fda.gov/cdrh/emc/pace.html>). EMI disruption of normal pacemaker function seems to occur only with cellular phones using digital technology, not those using analog technology. Most U. S. Cellular phones are the analog type and thus would not affect pacemaker function. Patients should ask questions about using digital cell phones as they become more popular. Still, people with pacemakers need to take some simple precautions to be sure that their cellular phones do not cause a problem. For example, holding the phone to the ear opposite the side of the body where the pacemaker is implanted will add some extra distance between the pacemaker and the phone. And since cellular phones transmit electromagnetic energy whenever they are "on" (even when they are not being used), pacemaker wearers might want to avoid placing a turned-on phone next to the pacemaker implant - that means not carrying the phone in a shirt or jacket pocket directly over the pacemaker. (<http://www.fda.gov/cdrh/emc/pace.html>) Physicians can minimize risks from cell phones by using particular models of pacemakers with appropriate filters, the correct leads, and optimal programming of the pacemaker.

CB radios, electric drills, electric blankets, electric shavers, ham radios, heating pads, metal detectors, microwave ovens, television transmitters and remote control televisions changers, in general, have not been shown to damage pacemaker pulse generators, change pacing rates, or totally inhibit pacemaker output. Several of these devices have a remote potential to cause interference by occasionally inhibiting a single beat. However, most people can continue to use these devices without significant worry about damage or interference with their pacemakers. If symptoms are felt when near any device, move 5 to 10 feet away from it and then check your pulse. The pulse rate should return to normal.

It is important to keep all physician and pacemaker clinic appointments.

A pacemaker needs regular check-ups when adjustments can be made and the battery checked. Home-based monitoring by telephone has become common. This type of monitoring allows the pacemaker to send data over the telephones. In this way, the pacemaker can be checked without a person having to come into the office as often. Usually, patients call in once a month or more if required to check the status of their pacemaker. Cardiac Datacorp-CardioCare (RayTel) is one such company dedicated to ensuring healthy and happy lifestyles for people with pacemakers.

New methods of sending pacemaker data to physicians are being examined. In October 2001, the FDA approved a new pacemaker that transmits information to a cell-phone like device carried by the patient. The phone sends the information to a customer service center, which then faxes the information to the patient's physician. This new form of transtelephonic monitoring differs from traditional checks in that the data can be transmitted at any time and the process does not require patient involvement. It can be programmed to perform checks as often as needed, from once a day to once a month ([www.yourtotalhealth.ivillage.com](http://www.yourtotalhealth.ivillage.com)). Patients with pacemakers need to know the indications of battery failure for their pacemaker and report these findings to their physician if they occur. Most pacemaker batteries can last from 5 to 10 years.

Today's pacemakers are truly extraordinary devices. They can be programmed in literally millions of possible combinations depending upon the patient's condition. On the horizon there is a new pacemaker in the clinical trials stage that is designed specifically to treat congestive heart failure. This device, called a biventricular pacemaker (or ventricular resynchronizer), uses an extra lead to synchronize the chambers of the heart so that they pump together. The results of using the biventricular pacemaker as a treatment for heart are still being researched.

New on the horizon is the heart powered pacemaker. Normally implanted pacemakers have to be replaced every 7 to 10 years. Although the risks are minimal, they do exist. Increasing the timeframe between replacements can decrease the risk of complications. Researchers at Stanford University, California feel that it better to have pacemakers receive power from the human body. These researchers suggest that implantable devices can be made self-powering by enabling a magnet to move from a coil or with the help of a piezoelectric element to move in a way that generates current (<http://www.topnews.in/heart-powered-pacemaker>).

Overall, people with pacemakers can do just about anything. They can take baths or showers without concern for the pacemaker. They can continue their usual sexual activity. Many run marathons, swim in races and lead very productive lives, for some even more so than before they received their pacemaker.

Nurses need to keep pace with the changing technological advances in pacemaker development. By staying aware of the changes in pacemaker development, nurses will be better equipped to advise patients and answer questions regarding pacemakers.

## Resources

American Heart Association  
Americanheart.org  
National Center  
7272 Greenville Ave  
Dallas, Texas 75231

Cardiac Datacorp-CardioCare (Raytel)  
7 Waterside Crossing  
Windsor, Ct. 06095-0727

800-367-1095

Medtronic, Inc.  
7000 Central Avenue, NE  
Minneapolis, MN 55432-3576  
612-574-4879  
1800-328-2518  
www.medtronic.com  
East Rutherford, N.J. 1800-537-0938

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## Course Exam

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1. The first battery powered pacemaker was invented in:  
 A. 1800  
 B. 1955

- C. 1957
  - D. 1958
2. Who is the person responsible for developing a combined electrocardiograph and pulse stimulator pacemaker?
- A. Dr. Hyman
  - B. Dr. Zoll
  - C. Dr. Lillehei
  - D. Dr. Bakken
3. A pacemaker is usually needed for all of the following conditions, except:
- A. Sick sinus syndrome
  - B. Complete heart block
  - C. Symptomatic bradycardia
  - D. Non-symptomatic bradycardia
4. Symptoms of bradycardia may include all except:
- A. Weakness
  - B. Syncope
  - C. Faintness
  - D. Hypertension
5. Complications that may occur in conjunction with a pacemaker insertion include all of the following except:
- A. Migraine
  - B. Dislodgement of lead
  - C. Pneumothorax
  - D. Infection
6. The initial VVI have special meaning when applied to the Universal Pacemaker Code. The second V stands for:
- A. indicates the chamber or chambers paced
  - B. indicates the chamber or chambers sensed
  - C. indicates the pacemaker activity or mode of response
  - D. indicates the antitachycardia functions
7. When patients first go home after pacemaker insertion the most important patient education instruction should include:
- A. Dental equipment will affect their pacemaker
  - B. Signs of infection
  - C. Magnetic resonance imaging (MRI) does not affect pacemakers
  - D. Cell phone use is prohibited

8. Pacemakers of the future may require replacement:
- A. Every month
  - B. Every year
  - C. Every 7 to 10 years
  - D. > 10 years
9. Patients with pacemakers should stay away from magnetic resonance imaging (MRI) and arc welding equipment because:
- A. A high-energy field can reprogrammed pacemakers
  - B. An electrode may get displaced
  - C. May be erosion of the pacemaker pocket
  - D. Develop an infection
10. Newer pacemakers are able to:
- A. Be programmed in countless combinations
  - B. Cause "R on T" phenomenon
  - C. Need reprogramming once a week
  - D. Not recommended for children