

REVIEW ARTICLE ON ARTIFICIAL CARDIAC PACEMAKER & IMPLANTABLE CARDIOVERTER DEFIBRILLATOR

¹G.Santoshini Reddy, ²Dr. K.V.Ratnamala

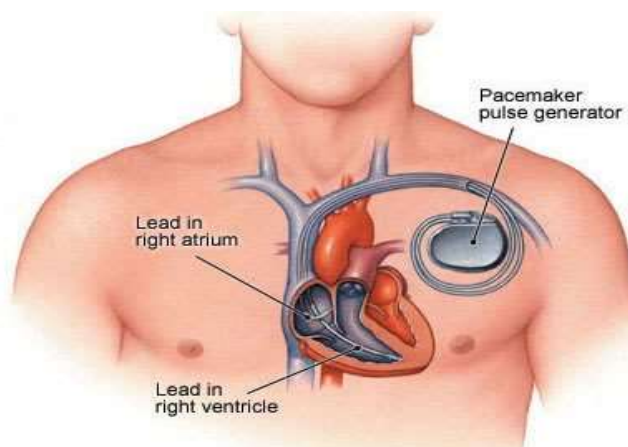
¹M.Pharmacy, ²Associate professor

Department of pharmaceuticals

RBVRR WOMEN'S COLLEGE OF PHARMACY, HYDERABAD, INDIA

ABSTRACT: A pacemaker is a small device that is placed in the chest or abdomen to help control irregular heart rhythms. This gadget utilizes low-vitality electrical heartbeats to provoke the heart to thump at a typical rate. Pacemakers are utilized to treat arrhythmias. Arrhythmias are issues with the rate or beat of the pulse. Amid an arrhythmia, the heart can pulsate too quick, too moderate, or with a sporadic musicality, Pacemakers can mitigate some arrhythmia indications, for example, weakness and swooning. A pacemaker additionally can help a man who has irregular heart rhythms continue a more dynamic way of life. Specialists likewise treat arrhythmias with implantable cardioverter defibrillators (ICDs). ICDs are like pacemakers. Be that as it may, other than utilizing low-vitality electrical heartbeats to control unusual heart rhythms, ICDs likewise can utilize high-vitality electrical heartbeats to treat certain risky arrhythmias.

KEYWORDS: pacemaker, implantable cardiac defibrillator, heart, arrhythmia.



INTRODUCTION: An arrhythmia is any disorder of the heart rate. It implies that the heart pulsates too rapidly, too gradually, or with an unpredictable pattern. Most arrhythmias result

from issues in the electrical arrangement of the heart. In the event that the arrhythmia is serious, one may require a heart pacemaker or an Implantable Cardioverter Defibrillator (ICD). They are gadgets that are implanted in the chest or abdomen .

A pacemaker helps control anomalous heart rhythms. It utilises electrical heartbeats to incite the heart to thump at an ordinary rate. It can accelerate a moderate heart cadence, control a quick heart musicality, and facilitate the assemblies of the heart. ⁽¹⁾

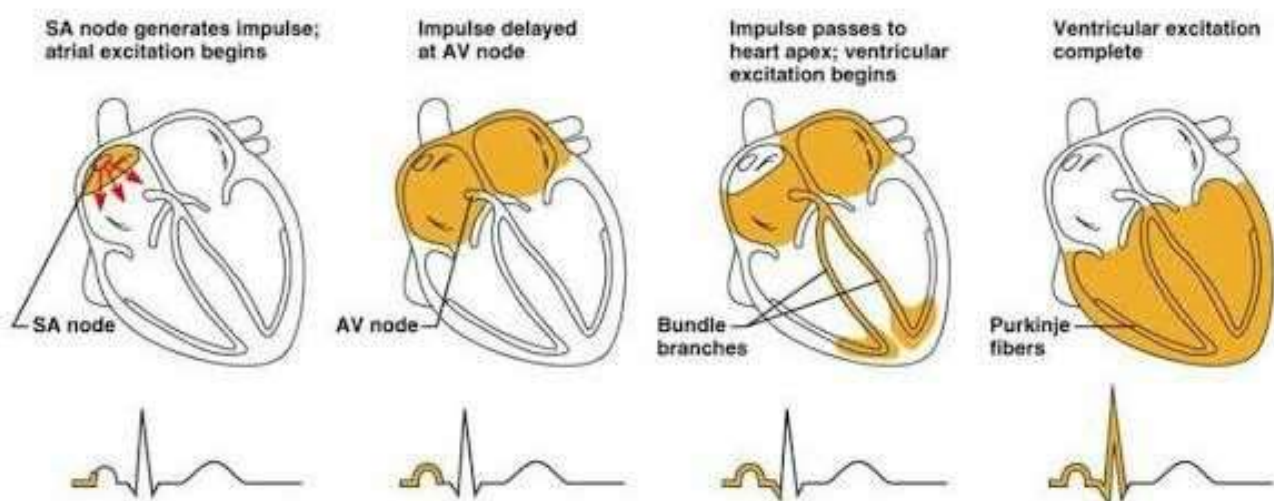
An ICD monitors heart rhythms. If it senses dangerous rhythms, it delivers shock. This treatment is called defibrillation. An ICD can help control dangerous arrhythmias, particularly those that can cause sudden heart failure. Most new ICDs can go about as both a pacemaker and a defibrillator. Numerous ICDs likewise record the heart's electrical pattern when there is an anomalous pulse. This can enable the doctor to design future treatment.

Getting a pacemaker or ICD requires minor medical surgery. The individual more often than not needs to remain in the hospital for a day or two, for the doctor to ensure that the device is functioning admirably. The individual will most likely have returned to the normal activities in a couple of days⁽²⁾.

BASIS OF CARDIAC PACING:

Ordinary heart movement starts in the sinus node, where cells with inherent automaticity go about as pacemaker cells. Electrical wave fronts at that point spread over the atria to the atrioventricular (AV) node, which they go through to enter the His-Purkinje framework to quickly spread to and depolarise the ventricles (Figure 1). At the point when characteristic cardiovascular automaticity or conduction integrity fails, the electrical sensitivity of heart tissue permits a little, outer electrical jolt to drive myocytes to edge, prompting depolarisation of neighbouring myocytes through vitality devouring natural procedures and the resulting spread of an electrical wave front, with close synchronous strong constriction by means of excitation-withdrawal coupling. Pacemakers provide that external stimulus. ⁽⁶⁾

Figure 1: The Cardiac Conduction System ⁽⁶⁾



UNDERSTANDING THE HEART'S ELECTRICAL SYSTEM:

The heart's electrical system controls the timing of the pulse by regulating:

- Heart rate, which is the number of times the heart pulsates every moment.
- Heart rhythm, which is the synchronised pumping activity of the four heart chambers.

The heart's electrical framework ought to keep up:

- A consistent heart rate of 60 to 100 thumps for each moment at rest. The heart's electrical framework likewise builds this rate to address the body's issues amid physical action and brings down it amid rest.
- An orderly contraction of the atria and ventricles (this is known as a sinus beat).

The heart muscle is made of tiny cells. The heart's electrical framework controls the timing of the pulse by sending an electrical signal through two sorts of cells:

- Conducting cells convey the heart's electrical signal.
- Muscle cells empower the heart's chambers to contract, an activity triggered by the heart's electrical signal. (3)

The electrical signal goes through the system of conducting cells "pathways," which stimulates upper chambers (atria) and lower chambers (ventricles) to contract. The signal can go along these pathways by methods for a perplexing response that enables every cell to enact one by it, empowering it to "go along" the electrical signal in an orderly way. As cell after cell quickly transmits the electrical charge, the whole heart contracts in one facilitated movement, making a pulse.

The electrical signal begins in a group of cells at the highest point of the heart called the sinus node or sinoatrial (SA) node. The signal at that point goes down through the heart, activating initial two atria and afterward two ventricles. In a healthy heart, the signal ventures rapidly through the heart, enabling the chambers to contract in a smooth, precise mold. As the signal spreads from the highest point of the heart to the base, it organises the planning of heart cell action.

⁽⁴⁾ The heartbeat occurs as follows:

- 1.The SA node (called the pacemaker of the heart) conveys an electrical signal.
- 2.The upper heart chambers (atria) contract.
- 3.The AV node sends an impluse to the ventricles.
- 4.The lower heart chambers (ventricles) contract or pump.
- 5.The SA node sends another signal to the atria to contract, which begins the cycle over again.

This cycle of an electrical signal followed by a contraction is one heartbeat . ⁽⁵⁾

WHO NEEDS PACEMAKER/ICD:

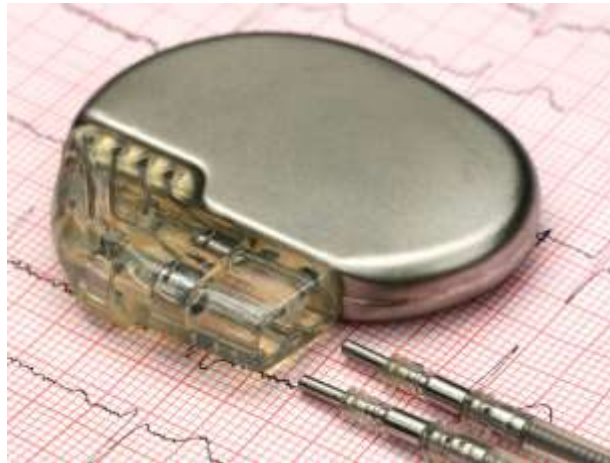
Doctors suggest pacemakers for some reasons. The most well-known reasons are bradycardia and heart block. Bradycardia is a pulse that is slower than normal. Heart block is a confusion that happens if an electrical signal is hindered or upset as it travels through the heart. Heart block can occur because of ageing, harm to the heart from a heart attack, or different conditions that upset the heart's electrical movement. Some nerve and muscle issue additionally can cause heart block, including strong dystrophy. (8)

Doctor likewise may suggest a pacemaker if:

- Ageing or coronary illness harms sinus node's capacity to set the right pace for the pulse. Such harm can cause slower than typical heartbeats or long delays between heartbeats. The harm additionally can make the heart switch amongst moderate and quick rhythms. This condition is called wiped out sinus disorder.
- If the individual has had a medicinal technique to treat an arrhythmia called atrial fibrillation. A pacemaker can help control the pulse after the procedure.
- If the individual needs to take certain heart medicines, for example, beta blockers. These drugs can moderate the pulse excessively.
- If the individual blacks out or has different side effects of a moderate pulse. For instance, this may happen if the main artery in the neck that supplies brain with blood is sensitive to pressure. Just rapidly turning the neck can make the heart beat slower than typical. Accordingly, the cerebrum probably won't get enough blood stream, making the individual black out or collapse.
- If the heart muscle has issues that reason electrical signals to move too gradually through the heart muscle. Pacemaker may give cardiovascular resynchronisation treatment (CRT) for this issue. CRT gadgets organise electrical motioning between the heart's lower chambers.
- Long QT disorder, which puts the individual in danger for unsafe arrhythmias.

Doctors likewise may prescribe pacemakers for individuals who have certain kinds of inborn coronary illness or for individuals who have had heart transplants. Youngsters, adolescents, and grown-ups can utilise pacemakers.

Before prescribing a pacemaker, doctor will consider any arrhythmia manifestations the individual has, for example, unexplained blacking out, or shortness of breath. Doctor likewise will consider whether the individual has a background marked by coronary illness, prescriptions utilised, and the consequences of heart tests. ⁽⁹⁾



WHAT IS A PACEMAKER?

A small battery-operated device that enables the heart to pulsate in a normal rhythm. There are two sections: a generator and wires (leads)

- The generator is a little battery-fueled unit.
- It produces the electrical impulses that stimulate the heart to pulsate.
- The generator might be embedded under the skin through a small incision.
- The generator is associated with the heart through modest wires that are embedded in the meantime.
- The impulses course through these leads to the heart and are coordinated to stream at general intervals similarly as driving forces from the heart's normal pacemaker would.
- Some pacemakers are outside and brief, not surgically implanted.

A pacemaker is prescribed to make the heart to beat all the more consistently if:

- Heartbeat is too moderate and frequently sporadic.
- Heartbeat is some of the time ordinary and now and then too quick or too moderate.⁽¹⁰⁾

WHAT IS IMPLANTABLE CARDIOVERTER DEFIBRILLATOR (ICD)?

An ICD is a battery-powered gadget placed under the skin that monitors the heart rate. Thin wires interface the ICD to the heart. If an unusual heart rhythm is identified, the gadget will convey an electric shock to reestablish an ordinary pulse if the heart is pulsating riotously and much too quick.

ICDs have been extremely helpful in anticipating sudden passing in patients with known, maintained ventricular tachycardia or fibrillation. Studies have demonstrated that they may have a part in counteracting heart failure in high-hazard patients who haven't had, yet are in danger for, perilous ventricular arrhythmias.⁽¹¹⁾

The American Heart Association prescribes that before a patient is thought to be a possibility for an ICD, the arrhythmia being referred to must be hazardous and doctors have precluded correctable reasons for the arrhythmia, such as:

- Acute myocardial infraction(heart attack)

- Myocardial ischemia (lacking blood flow to the heart muscle)
- Electrolyte unevenness and drug toxicity

ICD is suggested when the individual is in danger of a perilous ventricular arrhythmia in view of having:

- Heart attack
- Survived a sudden heart failure
- Long QT disorder
- Brugada disorder
- A inherent coronary illness or other hidden conditions for sudden heart failure

HOW DOES A PACEMAKER WORK?

It replaces the heart's defective natural pacemaker functions.

- The sinoatrial (SA) node or sinus node is the heart's natural pacemaker. It's a little mass of specific cells in the highest point of the right atrium(upper assembly of the heart). It delivers the electrical driving forces that cause the heart to pulsate.
- A chamber of the heart contracts when an electrical impulse or signal moves crosswise over it. For the heart to thump legitimately, the signal must go down a particular way to achieve the ventricles (the heart's lower chambers).
- When the heart's characteristic pacemaker is flawed, the pulse might be too quick, too moderate or sporadic.
- Rhythm issues likewise can happen on account of a blockage of the heart's electrical pathways.
- The pacemaker's heartbeat generator sends electrical driving forces to the heart to enable it to pump legitimately. A electrode is placed beside the heart wall and little electrical charges venture out through the wire to the heart.
- Most pacemakers have a detecting mode that hinders the pacemaker from sending driving forces when the pulse is over a specific level. It enables the pacemaker to fire when the pulse is too moderate. These are called request pacemakers⁽¹³⁾

HOW DOES IMPLANTABLE CARDIOVERTER DEFIBRILLATOR WORK?

It knows when the pulse isn't typical and endeavours to restore the pulse to ordinary.

- If the ICD has a pacemaker include, when the pulse is too moderate, it functions as a pacemaker and sends little electric signals to the heart.
- When the pulse is too quick or disorganised, it gives defibrillation shock to stop the irregular rhythm.
- It works 24 hours per day.

A battery-fueled heartbeat generator is embedded in a pocket under the skin of the chest or abdomen, frequently just underneath the collarbone. The generator is about the size of a pocket watch. Wires or leads keep running from the pulse generator to positions on the surface of or inside the heart and can be introduced through veins, eliminating with the requirement for open-chest medical procedure.

New gadgets additionally give "overdrive" pacing to electrically change over a supported ventricular tachycardia (quick heart beat) and "reinforcement" pacing if bradycardia (moderate heart musicality) happens. They likewise offer a large group of other refined capacities, for example, stockpiling of distinguished arrhythmic occasions and the capacity to perform electro physiologic testing. Stored information can help doctor to enhance the ICD as per quiet needs. ⁽¹⁴⁾

DEVICES THAT MAY INTERFERE WITH PACEMAKERS & ICD:

Anti-theft systems (also called electronic article surveillance or EAS): Interactions with EAS frameworks are probably not going to cause clinically noteworthy manifestations in many patients. In any case, the American Heart Association prescribes that the patient should:

- Be aware that EAS frameworks might be covered up or disguised in passages and exits in numerous organisations.
- Not remain close to the EAS framework longer than is vital.
- Not incline toward or stand near a hostile to anti-theft system.

Metal detectors for security: Interactions with metal detectors are probably not going to cause clinically noteworthy side effects in many patients. In any case, the American Heart Association suggests that:

- Person ought not remain close to the metal indicator longer than is essential.
- Should not incline toward or remain against the framework.
- If scanning with a hand-held metal indicator is fundamental, the security staff ought to be educated that individual has a pacemaker/ICD. The security staff ought to be advised not to hold the metal locator close to the device any more extended than is completely important, or ought to be requested for an alternative form of personal search. ⁽¹⁵⁾

Cell phones: As of now, telephones accessible in the United States (under 3 watts) don't seem to harm pulse generators or influence how the pacemaker/ICD functions.

- Technology is quickly changing as the Federal Communications Commission (FCC) makes new frequencies accessible.
- Newer mobile phones utilising these new frequencies may make pacemakers/ICD less reliable.
- A group of wireless organisations is examining that possibility.
- Bluetooth headsets don't seem to interfere with pacemakers/ICD.

MP3 player headphones: Most contain a magnetic substance and research has recorded that setting the earphones excessively near the pacemaker/ICD caused impedance

- Never lay head on the chest of a man with pacemaker while wearing earphones.
- Both the ear bud and clasp on sorts of earphones can cause obstruction

Power-generating equipment, arc welding equipment and powerful magnets: For example, found in some therapeutic gadgets, heavy equipment or engines can obstruct pulse generators.

- Pacemakers may not work appropriately, if the individual is nearer to such equipment.
- Person ought to follow the guidelines about being around such gear.
- Headphones ought to be kept no less than 1.2 inches (3 cm) far from the pacemaker/ICD⁽¹⁶⁾

Short-wave or microwave diathermy: A medicinal technique that utilizes high-frequency, high-force signals for physical therapy. These may sidestep the pacemaker's clamor security and meddle with or forever harm the pulse generator. Not prescribed for individuals with ICD's.

Extracorporeal shock-wave lithotripsy (ESWL): A noninvasive treatment that uses hydraulic shocks to break down kidney stones.

- This technique might be done securely in many patients, with some reprogramming of the pacing.
- Patient will require watchful follow-up after the strategy and for a while to make sure pacemaker/ICD is working legitimately.
- ESWL ought to be stayed away from patients with specific sorts of pacemakers embedded in the abdomen.⁽¹⁷⁾

Magnetic resonance imaging (MRI): A noninvasive diagnostic instrument that uses a powerful magnet to create pictures of internal organs and functions.

- Metal objects are pulled in to the magnet and are ordinarily not permitted close MRI machines.
- The magnet can interfere with the pacing and restrain the yield of pacemakers/ICD.
- The patient should check with the doctor about regardless of whether to experience a MRI, and any dangers and advantages of having this test with a pacemaker/ICD.

Radiofrequency ablation (RFA): A medicinal method that utilizes radio waves to deal with a wide assortment of arrhythmias.

- RFA is generally performed before the pacemaker is embedded.
- Studies have demonstrated that most lasting pacemakers aren't antagonistically influenced by radio frequencies amid catheter removal.
- Doctor ought to carefully assess the pacing framework after the procedure.⁽¹⁸⁾

Therapeutic radiation (such as for cancer treatment): May harm the device's circuits.

- The level of harm is erratic and may shift with various systems.

- The hazard is huge and develops as the radiation measurement increments.
- The American Heart Association suggests that the device might be shielded however much as could reasonably be expected and moved if it lies directly in the radiation field.
- ICDs have been appeared to be more sensitive to radiation treatment impedance than pacemakers.

Transcutaneous electrical nerve stimulation (TENS): A restorative device used to assuage intense or incessant agony with terminals set on the skin and associated with a heartbeat generator.

- Most studies have demonstrated that TENS once in a while represses reconstructing the pulse generator bipolar pacing.
- It may in some cases quickly restrain unipolar pacing. This can be dealt by reprogramming the pulse generator⁽¹⁹⁾

SAFE UNDER NORMAL USE:

The following household items are generally safe to use with a pacemaker/ICD as long as they are in good working condition and used as intended:

- | | |
|--|---|
| • Air purifiers | • Patient alert devices |
| • Blenders | • Personal computers |
| • CD/DVD Players | • Personal digital assistants |
| • Clothes washing machines | • Portable space heaters |
| • Electric blankets | • Radios (AM and FM) |
| • Electric can openers | • Remote controls (TV, garage door, stereo, camera/video equipment) |
| • Electric invisible fences | • Stoves (electric or gas) |
| • Electric toothbrushes | • Tanning beds |
| • Fax/copy machines | • Televisions |
| • Hair dryers | • TV or radio towers (safe outside of restricted areas) |
| • Heating pads | • Vacuum cleaners |
| • Hot tubs/whirlpool baths | • VCRs |
| • Microwave ovens | • Video games |
| • Ovens (electric, convection, or gas) | |
| • Pagers | |

SAFE TO USE WITH EXTRA PRECAUTIONS:

Items that should not be placed directly over the pacemaker/ICD, but are otherwise safe to use

- Cordless (household) telephones
- Electric razors
- Hand-held massagers

- Portable MP3 and multimedia players (such as iPods®) that do not also function as a cellular phone
- NOTE: While portable MP3 players themselves should not interfere with the pacemaker/ICD, the headphones or earbuds should be stored at least 6 inches (15 cm) away from the device and one should avoid draping the headphones around the neck.

Items that should remain at least 6 inches (15 cm) away from pacemaker/ICD:

- Cellular phones, including PDAs and portable MP3 players with integrated cellular phones
 - Devices transmitting Bluetooth® or Wi-Fi signals (cellular phones, wireless Internet routers, etc.)
 - Headphones and earbuds
- NOTE: It is safe to use headphones and earbuds, but you should refrain from draping them around the neck and from storing them in a breast or other shirt pocket.
- Magnetic wands used in the game of Bingo ⁽²⁰⁾

Items that should remain at least 12 inches (30 cm) away from the pacemaker/ICD:

- Battery-powered cordless power tools
- Chainsaws
- Corded drills and power tools
- Lawn mowers
- Leaf blowers
- Remote controls with antennas
- Shop tools (drills, table saws, etc.)
- Slot machines
- Snow blowers
- Stereo speakers

Items that should remain at least 24 inches (60 cm) away from the pacemaker/ICD:

- Arc welders
 - CB and police radio antennas
 - Running motors and alternators, especially those found in vehicles
- NOTE: Avoid leaning over running motors and alternators of a running vehicle. Alternators create large magnetic fields that can affect your pacemaker. However, the distance required to drive or ride in a vehicle is safe. ⁽²¹⁾

Using Cellular Phones Safely:

Cellular phone is a source of EMI and could affect the pacemaker's operation. This interaction is temporary, and moving the phone away from the device will return it to proper function. To reduce the chance of interaction, follow these precautions:

- Maintain a distance of at least 6 inches (15 cm) between the cell phone and the pacemaker. If the phone transmits more than 3 watts, increase the distance to 12 inches (30 cm).

- Hold the cellular phone to the ear on the opposite side of the body from the pacemaker.
- Do not carry a cell phone in a breast pocket or on a belt if that places the phone within 6 inches (15 cm) of the pacemaker.

Not safe to use:

- Body-fat measuring scales
- Jackhammers
- Magnetic mattresses and chairs
- Stun guns ⁽²²⁾

MARKETED PRODUCTS:

1. BOSTON SCIENTIFIC PACEMAKERS: ⁽²³⁾

- **ACCOLADE and ESSENTIO pacemaker:** ACCOLADE and ESSENTIO are Boston Scientific's most advanced Pacemakers offering the assurance of Automatic Daily Monitoring to improve patient compliance, actionable data to enable earlier intervention, and the longest projected longevity in the industry



- **ACCOLADE and ESSENTIO MRI pacemaker:** Boston Scientific's most advanced pacemakers are now MR-conditional. ACCOLADE MRI and ESSENTIO MRI models can be used as part of the Image Ready MR-Conditional Pacing System for safe and effective scanning in 1.5T and 3T MRI environments when MRI Conditions of Use are met



- **INGENIO and ADVANTIO pacemakers:** INGENIO and ADVANTIO pacemakers from Boston Scientific define a new era in pacing. Both leverage key aspects of

our innovative high-voltage platform and incorporate new features, therapies and diagnostic options.



- **VITALIO pacemaker:** VITALIO lets the heart take the lead, intervening only when appropriate. With features including respiration-based pacing for rate response, wireless connectivity and automaticity in both chambers – the VITALIO pacemaker lets patients get back to what's important in life.



2. MEDTRONIC PACEMAKERS: ⁽²⁴⁾

- **AZURE pacemaker:** The Azure pacemaker wirelessly and securely transfers heart device information to the doctor if it detects changes in heart. These devices are safe for use in the MRI environment when specific conditions are met. Azure pacemaker may last longer, and offers exclusive algorithms to accurately detect and reduce the likelihood of experiencing atrial fibrillation.



- **ADVISA MRI pacemaker:** The Advisa MRI SureScan pacemaker is the second generation FDA-approved pacing system designed for safe use in the MRI environment when specific conditions are met. Advisa is available in single and dual chamber options.



- **ADAPTA pacemaker:** Adapta is a “physiologic” pacemaker. It waits for the natural heartbeat before delivering the pacing impulse to avoid unnecessary pacing. The Adapta pacemakers are also completely automatic, constantly adjusting their settings and adapting to meet the heart’s needs



3. MEDTRONIC ICD: ⁽²⁴⁾

- **VISIA AF MRI SURESCAN ICD:** The only single chamber ICD with a traditional lead, which enables physicians to continuously monitor, diagnose, and manage atrial fibrillation (AF) patients. Also designed for safe use in the MRI environment when implanted as a system and when specific conditions are met.



- **EVERA MRI SURESCAN ICD:** The first ICD system to be FDA approved for use in the 1.5T and 3T MRI environment when implanted as a system and when MR conditions for use are met.



BATTERY REPLACEMENT:

Pacemaker batteries last between 5 and 15 years (average 6 to 7 years), depending on how active the pacemaker is. Doctor will replace the generator along with the battery before the battery starts to run down.

Replacing the generator and battery is less-involved surgery than the original surgery to implant the pacemaker. Pacemaker wires also may need to be replaced eventually.

Doctor can tell whether the pacemaker or its wires need to be replaced during the follow-up visits.

LIVING WITH PACEMAKER/ICD:

1. Understanding the device-how it works, what to avoid while having the device
2. The heart rate and blood pressure should be monitored from time to time
3. Medication should taken as prescribed by the doctor
4. Pacemaker/ICD ID card should be carried by the patient ,so that in case of emergency the doctor can know what they are dealing with
5. Keeping up with the checkup appointments. ⁽²⁵⁾

CONCLUSION: The artificial pacemaker and ICD have been around for more than 50 years. Innovation has enabled us to progress hugely in the field of medicine. Today engineers are discovering courses for making longer enduring batteries and an approach to create and supplant the real pacemaker situated in the bodies now. With these advances in innovation, artificial pacemakers are changing the lives of thousands consistently. In spite of the fact that the pacemakers and ICD's have impedances with a few gadgets, they have possessed the capacity to spare numerous lives all through. By taking certain preventive measures like remaining away from gadgets that reason impedance to pacemakers/ICD and following the guidelines given by doctor, the individual can carry on with a decent life.

The improvement of artificial pacemakers for the electrical control of the heart cadence has enormously upgraded the doctor's capacity to treat cardiovascular dysarrhythmias. Pacemakers have been valuable in treating Stokes-Adams disorder and symptomatic bradycardias; they have helped control the event of tachyarrhythmia's and have assumed a critical part in the administration of arrhythmias going with myocardial areas of localised necrosis. With their

more successive utilise, pacemakers have added as far as anyone is concerned of fundamental conduction and common pacemaker issue. As new signs for artificial pacemaking have been illustrated, more unpredictable heartbeat generators have been created, and newer methods found for their insertion. Disregarding recent improvement the pulse generators in general have a restricted helpful lifetime

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