

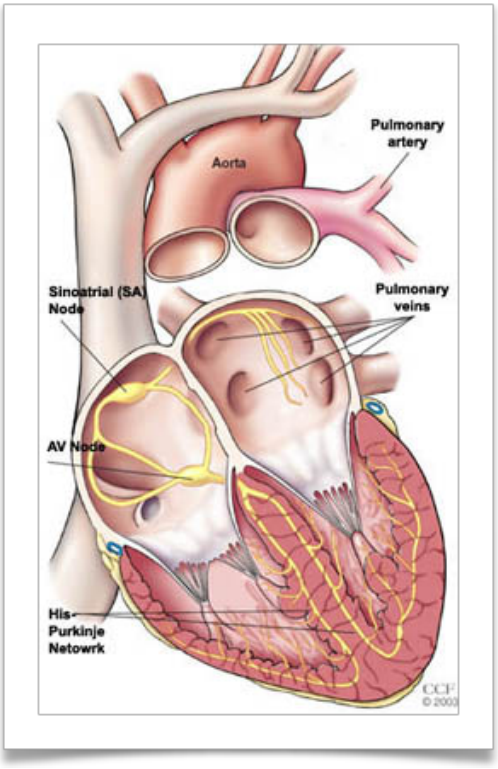
Medicine for Managers

Dr Paul Lambden BSc MB BS BDS FDSRCSEng MRCS LRCP DRCOG MHSM FRSM

What is a cardiac pacemaker?

Day in, day out your heart beats and the pumping action which it generates circulates the five litres or so of blood round the body providing oxygen and nutrients and carrying away carbon dioxide and waste products. In an average 75 year life time the heart will beat over two-and-a-half billion times. Sometimes the mechanism goes wrong but a simple pacemaker may control the problem.

To understand what can go wrong and why a pacemaker may be essential, it is necessary to understand the way in which the electrical stimuli to achieve muscle contraction are generated.



The heart consists of four chambers. Blood enters the heart from the great veins (the ***venae cavae***) into the ***right atrium*** (shown top left as you look at the picture).

The blood is pushed through the ***tricuspid valve*** into the ***right ventricle*** (bottom left on the picture) and travels through the ***pulmonary artery*** to the lungs where the blood is oxygenated.

The blood then returns into the ***left atrium*** (shown top right in the picture) and through the ***mitral valve*** into the ***left ventricle*** (bottom right of the picture) which pushes the blood into the general circulation supplying the whole body. OK, so much for the A level biology.

The four chambers work together to push the blood (which arrives at the heart at zero pressure) through the lungs and subsequently out to the body at high pressure. The pumping effect is achieved by alternate contraction and relaxation of the chambers.

What makes the heart tick (and pump) is a complex electrical system which is laid out through the heart, as shown in yellow in the picture opposite.

Medicine for Managers articles are not intended to be a source of medical advice. Their purpose is to familiarise the non-medical reader about current key medical disorders. Any medical or medicinal products mentioned by name are examples only and should not be regarded as an endorsement of their use.

The Sinu-Atrial Node:

Also sometimes called the heart's natural pacemaker is situated high in the right atrium and consists of a cluster of cells which have the ability to spontaneously produce an electrical impulse.

In a healthy heart the S-A node repeatedly and continuously produces the impulses which then spreads through the walls of the atria and causes them to contract forcing blood into the ventricles.

I cannot begin to describe the complex biochemistry behind the achievement of this effect but suffice it to say that electrical charges change from positive to negative resulting in the flow of current.

The S-A node sets the rate and rhythm of your heartbeat and, in a normal healthy heart, it is referred to as normal sinus rhythm because the S-A node fires regularly.

The Atrio-Ventricular Node

The A-V node is another cluster of cells located low in the atrium (see diagram) and the wave of electrical impulses from the S-A node reaches the A-V and it acts like a gateway which slows the electrical signal before it spreads to the ventricles so that the atria contract first and push blood into the ventricles before the ventricles themselves contract.

If the A-V node did not slow down the impulse, the atria and ventricles would effectively contract at the same time resulting in blood in the atria being pushed forwards at the same time as blood in the ventricles was pushed backwards. Blood would therefore not move.

The Atrio-Ventricular Bundle

The electrical impulse continues downwards from the A-V node in the ***atrio-ventricular bundle of His*** from which branch specialised fibres composed of modified muscle fibres and called ***Purkinje fibres***. They conduct the impulses through the cardiac muscle of the ventricles and co-ordinate the contractions of the heart chambers.

Once the impulse has spread through the Purkinje fibres, the sinu-atrial node fires and starts the process again.

At rest the normal heart beats at around 60 to 85 times a minute. It can be speeded up by a variety of factors including exercise and emotion. Having a fever increases the heart rate by about ten beats per minute for every degree Centigrade rise in temperature. Medications of various types may also have an effect on the rate at which the heart beats.

Arrhythmia (pronounced a-rith-me-ah)
As the name suggests an arrhythmia is an abnormality of heart rhythm. Roughly one in thirty people in the United Kingdom have an arrhythmia. It does not stop someone leading a normal life with normal activities.

There are a number of types of arrhythmia. They may cause the heart to beat irregularly, too slowly, too quickly or inefficiently. The purpose of a pacemaker is to provide low-energy electrical impulses to prompt the heart to beat at a normal rate.

A pacemaker is one of the array of treatments for managing various types of heart disease where a particular arrhythmia is a key component.

Therefore, when a patient develops cardiac symptoms, the GP or specialist will review the symptoms, the results of investigations and any medical treatment used to assess the potential success of a pacemaker.

When the heart's action is compromised, patients may feel faint, lightheaded, dizzy,

Medicine for Managers articles are not intended to be a source of medical advice. Their purpose is to familiarise the non-medical reader about current key medical disorders. Any medical or medicinal products mentioned by name are examples only and should not be regarded as an endorsement of their use.

lethargic or breathless. They may have palpitations or be aware of the heart beating irregularly or slowly.

The pacemaker itself is a computerised device which generates electrical stimuli from which pass wires with sensors (electrodes) at their ends.

The electrodes detect the heart's electrical activity and send data to the device through the electrodes. If the device identifies an abnormal heart rhythm, it will direct the impulse generator to send electrical impulses to the heart. The most modern pacemakers can monitor other factors to ensure that the heart rate is appropriate to the patient's situation.

Pacemakers have been in use since the late 1950s and something like 2.5 million people have been fitted with one.

Originally, pacemakers were plugged into the wall AC socket which limited the distance a patient could travel to the length of wire between plug and device. Of course, a power failure could mean death!

At the end of the 1950s, battery powered pacemakers were developed and the first device was fully implanted within a patient in 1960.

By the mid 1960s, the technique had improved such that they could be implanted without open heart surgery. In the mid 1970s, lithium batteries made their first appearance providing much more sustainable rhythm management.

Since then all kinds of developments have occurred. They are smaller, lighter, easier to install and can be programmed from outside the body. They can now adjust the impulse programme to alter the rate according to the person's exercise and cardiac demand.

Battery life is now an average of 6-7 years and they may last as long as 15.

Care still must be taken because such things as metal detectors, electric generators and even cell phones can disrupt pacemakers.

So can medical procedures such as MRI scans, electrocautery in surgery and shock-wave therapy such as that used in destroying kidney stones.

Pacemakers are most commonly used for the treatment of two types of arrhythmia

Bradycardia (pronounced brad-ee-card-ee-ah).

This is a condition where the heart beat is below sixty beats a minute. Symptoms usually do not arise until it falls below fifty beats a minute and are normally weakness, dizziness, fatigue and sweating.

At lower rates patients may faint. The condition has a lot of causes which may either be to do with the heart (cardiac causes) or other factors (non-cardiac causes).

Cardiac causes are generally associated with disturbances of the sinu-atrial or atro-ventricular nodes, often as a result of restriction of blood flow (called ***ischaemia***).

Non-cardiac causes are generally due to drug abuse, abnormalities of endocrine glands such as the thyroid or disturbances in body chemistry leading to imbalance of electrolytes.

Heart Block.

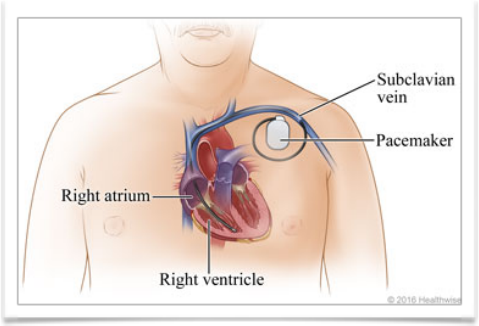
This is a form of bradycardia where the electrical signals that spread from the atria to the ventricles are blocked or partially blocked resulting little or no symptoms at its mildest, through light-headedness and fainting to chest pain, breathlessness and

Medicine for Managers articles are not intended to be a source of medical advice. Their purpose is to familiarise the non-medical reader about current key medical disorders. Any medical or medicinal products mentioned by name are examples only and should not be regarded as an endorsement of their use.

collapse. It may be caused by anything that results in interruption of the electrical impulse normally at or below the atrio-ventricular node. Treatment is usually by the insertion of a pace-maker to take over the rhythm of the heart.

Fitting the pacemaker is these days relatively straightforward. The prospective patient will have tests to ensure appropriateness of the technique and fitness for surgery. These will include blood tests and ECG and often echocardiography.

The technique, which usually takes about one to two hours, is usually done under



local anaesthetic. The local anaesthetic is injected into the area where the surgery will be performed.

A sedative drug is also given intravenously to relax the patient during the procedure. The most common technique involves making a 5-6 centimetre cut below the collarbone on the left side of the chest and pacemaker wires are inserted into a vein.

The leads are then guided along the vein into the right atrium of the heart with the aid of X-ray scanning.

They are lodged in the heart tissue. The other ends of the leads are connected to the pacemaker which is commonly a small spherical box-like structure which is located in a pocket created by the surgeon between the chest muscle and the skin of the upper chest.



Most patients stay overnight in hospital. After a short period of recovery patients can resume an almost entirely normal life and forget about the device that keeps them alive every day.

What an amazing invention the pacemaker is. It can truly be said to have saved and prolonged the lives of millions.

Let me finish by raising a metaphorical glass to ***Wilson Greatbatch***, the electrical engineer who invented the implantable pacemaker at the beginning of the 1960s.

He died in 2011 but his legacy lives on, helping people every day.

paullambden@compuserve.com

Medicine for Managers articles are not intended to be a source of medical advice. Their purpose is to familiarise the non-medical reader about current key medical disorders. Any medical or medicinal products mentioned by name are examples only and should not be regarded as an endorsement of their use.