

Young Scientist Program Anatomy Teaching Team



“Medical Interventions for Cardiac Diseases”

Lesson Goals:

1. Be able to name some ways a heart attack can be treated.
2. Know what a stent is and how it helps get rid of a coronary artery blockage.
3. Understand that pacemakers and defibrillators deliver shocks to pace or reset the heart, respectively.
4. Understand that an LVAD is a pump that can help meet the demands of the body for a patient with heart failure.

Introduction

There are many things that can go wrong with the heart. Some of these problems have been briefly mentioned in the previous demonstrations that you have seen today, and some of these problems you have probably learned about by interacting with friends, family members, or relatives. The first step toward treatment of a heart problem is diagnosis with various methods you have learned about. Yet, even if we know exactly what is wrong with the heart of a specific patient how can doctors alleviate or cure these problems, and what tools do they have to combat these problems? We are going to talk about what doctors can do to alleviate, cure, or solve some of the most common problems with the heart. Many of these procedures are incredibly important in medicine as they often can dramatically restore very ill people to a near normal way of life.

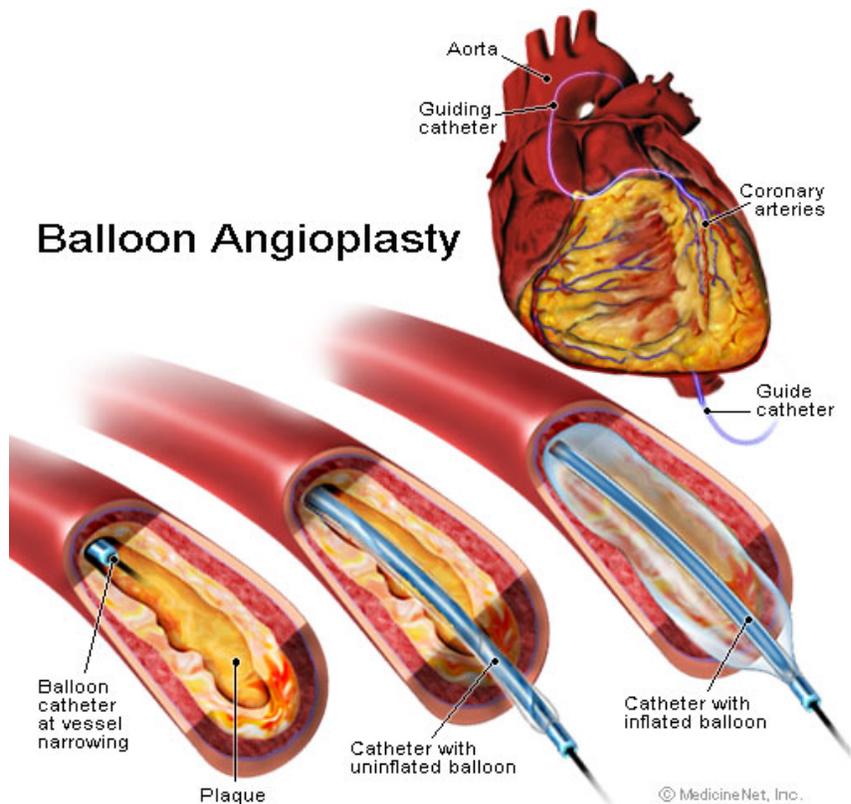
What can doctors do to alleviate the effects of a heart attack (myocardial infarction)?

By far the most important principle is treating people who are or have experienced a heart attack is to remove the blockage in the coronary artery as fast as possible (within 3 hours)! Again, the sooner the blockage is removed the less tissue will be damaged. **So how do you remove or solve the problem of a blockage in the coronary artery?** Think of a similar problem with a clog in a drain or plumbing. How do you remove the clog? Drains (chemical), router (mechanically), build a new pipe around the blocked old pipe (bypass). All of these solutions have very similar counterparts in medicine.

Chemically breaking up the blockage. Almost all of the blockages that cause sudden (acute) heart attacks contain some type of **blood clot**, which is made up of various **blood proteins** and **platelets** that are stuck together by very specific molecular bonds. One way to break up this blockage is to chemically disrupt the bonds that are holding the blood cells, platelets, and proteins together. One drug that can do this is **aspirin**. Aspirin decreases the ability of platelets to clot, which over time allows the blockage to break up on its own. Another similar drug family are the **lytics** (e.g. streptokinase, urokinase, etc.). These drugs actively promote the breakdown of the protein components of the

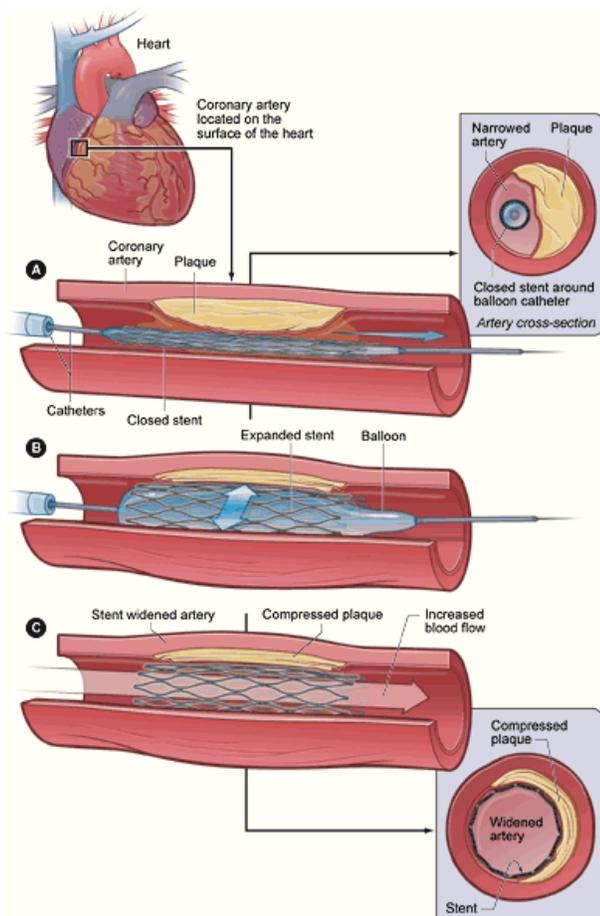
blockage (similar to Draino) and therefore are very powerful at destroying the blockage. Yet, this can also be very dangerous because they can also lead to bleeding in other areas of the body, especially the brain!

Mechanically breaking up the blockage. One of the most popular methods to remove this blockage is to physically remove it. This can be accomplished by by a number of different methods, all of which use very small wire/tubing (**catheters**) to get near the blockage from inside the coronary artery. To accomplish this a small incision is made in one of the arteries in your leg or arm and the catheter is inserted into the blood vessel.

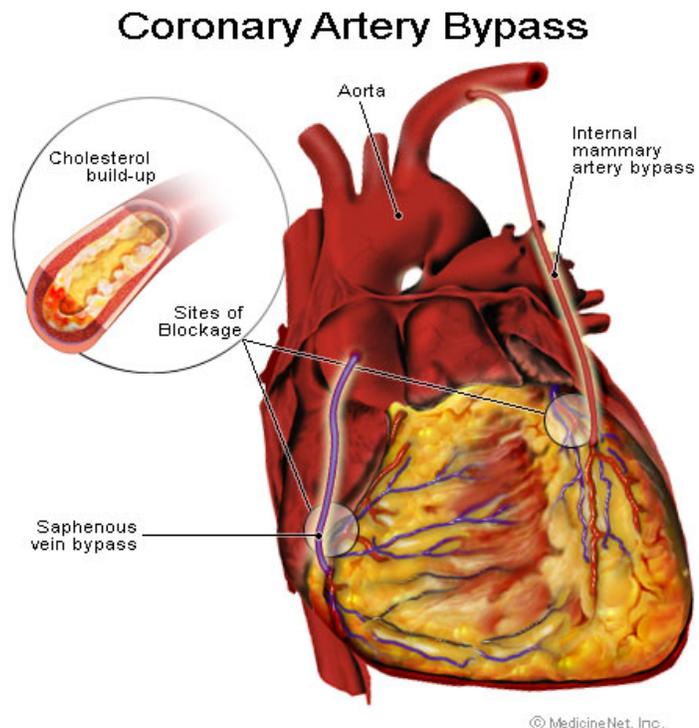


Next the catheter is routed up towards the heart and into the coronary arteries, with the help of various imaging systems (**fluoroscopy + angiography**). This gets the tip of the catheter very close to the site of the blockage. Different catheters have different devices on their tips that can then disrupt the blockage. One type of catheter has a **small balloon** on the end which is inflated, pushing all the blockage in the artery against the vessel's wall. This is called **balloon angioplasty**.

A more common, and preferable, technique uses a similar catheter with a balloon on the end that it enclosed inside a small metal cage called a **stent**. A stent is like a very small tubular piece of chicken wire. The procedure is performed exactly like balloon angioplasty, yet this time the stent expands around the balloon so that once the balloon and catheter are removed the small metal cage remains in place to hold the blockage back against the vessel wall. This technique has been shown to have much longer lasting effects and lower rates of recurrence than balloon angioplasty alone. Some stents are even coated with drugs to make the effect even stronger!



Bypassing the blockage. While catheter procedures are usually preferred, due to their less invasive and lower risk nature, sometimes too many arteries are blocked or the blockage is too severe to be remedied by stents alone. In this case some patients will undergo **bypass surgery**. While many people have heard of this term, in the hospital it is called a **CABG (cabbage)**, which stands for **coronary artery bypass graft**. In this procedure a surgeon will put the patient under anesthesia, open their chest cavity, and then sew a tiny tube to the aorta (above the blockage) and to the affected coronary artery (below to the blockage). This allows the blood to bypass the blockage and get to the heart tissue without having to disturb the blockage. Usually one of the patient's own veins is taken to produce this bypass



What can doctors do to alleviate the effects of a cardiac electrical problem (arrhythmia)?

In general the key to treating these pacing conditions is to restore the proper rate and/or rhythm of the heart. This can be accomplished by both **chemical treatments (antiarrhythmic drugs)** or by **electrical means** (through implantable devices that electrically interact with the heart).

Antiarrhythmic Drugs. In some types of conduction/pacing problems the source of the bad electrical stimuli are select patches of **heart cells that are overly excitable**. These cells fire small bursts of electricity even when they are not supposed to, and this electrical signal conducts to neighboring cells and tissues out of order to the normal electrical conduction scheme. In some occasions these pacing problems can be controlled by **certain drugs that artificially suppress the excitability (irritability)** of these problematic cells.

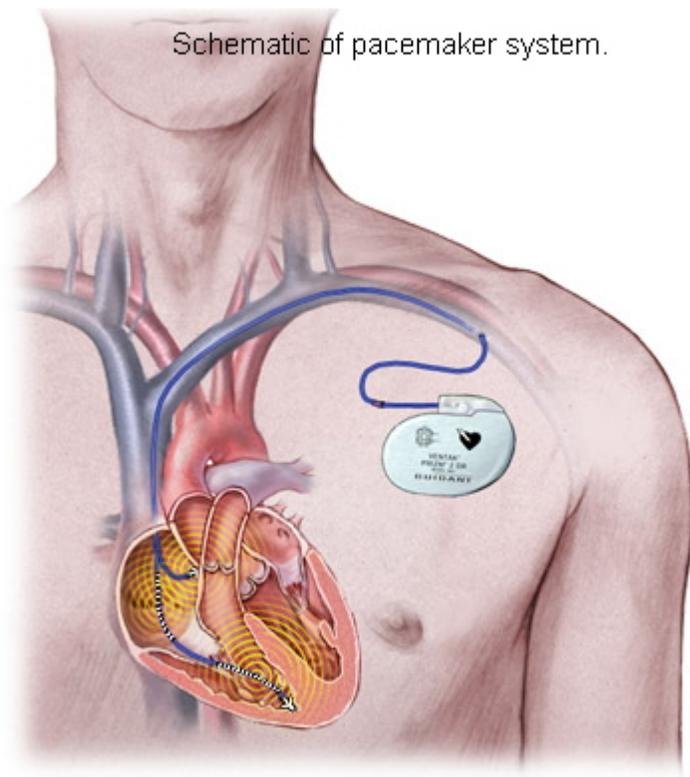
Pacemakers. In some types of heart conditions, the heart rate is abnormal. In these conditions the heart may not beat fast enough and the patients may be at risk for passing out. In order to restore the correct heart rate doctors may use an implantable **pacemaker**. Pacemakers are implanted in the chest, and have wires coming out that go into the heart. This device **sends out small electrical pulses** that shock the heart muscle and cause a heart beat to occur, usually at a rate of 60 beats/second.

When might a pacemaker not work so well? Is the heart rate always constant? What happens during exercise?

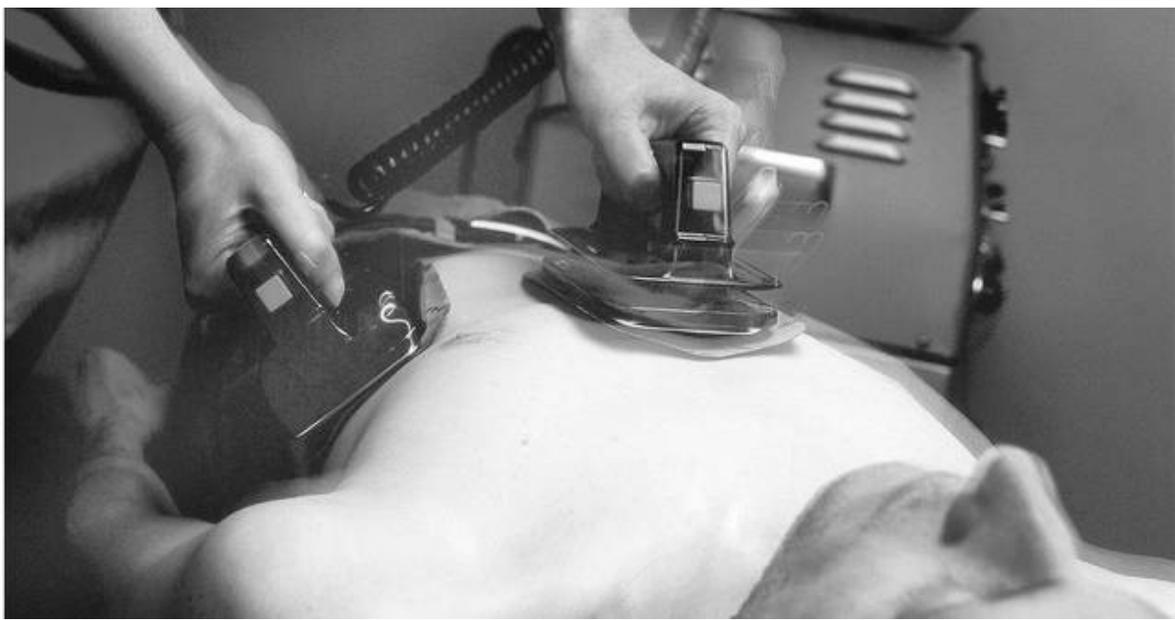
Modern pacemakers sometimes have additional inputs that can sense when patients are working out, running, or sleeping, and can adjust the rate of electrical pulses it sends to the heart. Also, many

devices can record and store different programs and data so that doctors can tune the pacemaker to better serve the patient's specific condition.

Defibrillation. Some electrical conduction and pacing problems that occur in the heart can be fatal. Conditions such as ventricular tachycardia and ventricular fibrillation cause rapid, uncoordinated contraction, thus little functional blood output to the lungs or body. **Asystole**, commonly known as **flatlining**, is a condition where the heart is not beating at all. One way that doctors can treat conditions like these is through the use of a **defibrillator**. You may have seen these on the walls of airports (**AEDs**), or have seen them on **ER television shows where the doctors shock the patients** who are dying. A defibrillator can deliver a large shock to the patient's chest through two paddles containing metal contact pads. This large electric shock resets the electrical activity within the heart.



Why do people jerk around and twitch when they are shocked with a defibrillator? What other organs/tissues rely on electrical signals?

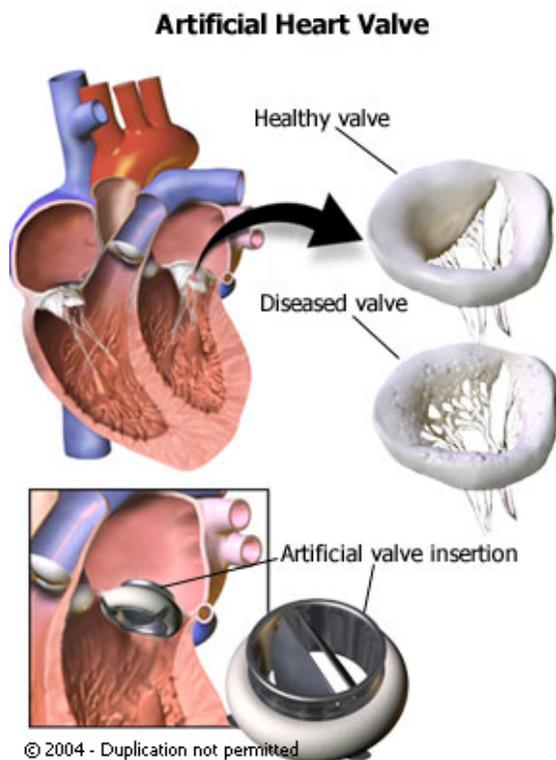


In some patients the risk of an arrhythmia arising is very high. For these patients the risk of being without an external defibrillator is too great, and therefore doctors can implant an **implantable cardiac defibrillator (ICD)** into the patient's body. These devices look very similar to a pacemaker device, but serve the same function as external defibrillators. Specifically, these devices sense the electrical activity of the heart, determine if it is dangerous to the patient or not, and then deliver a shock to the heart if the problem does not resolve on its own. **More modern devices can actually serve as both pacemakers and defibrillators at the same time.**



What can doctors do valvular heart disease?

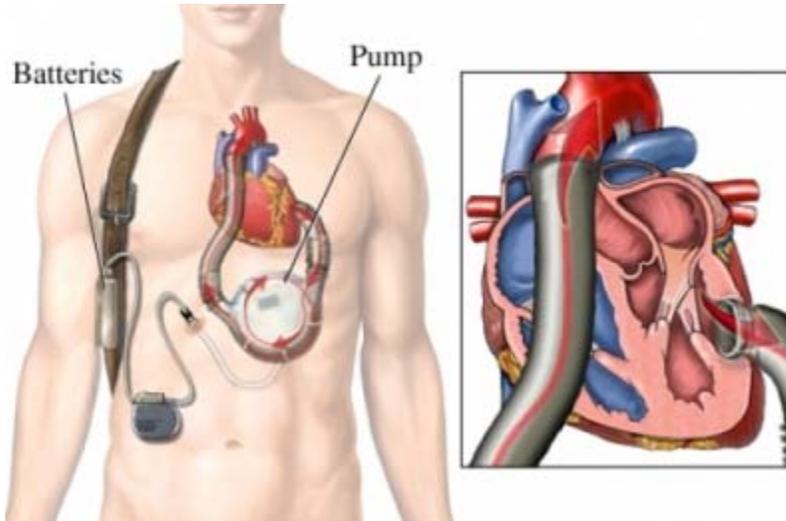
Valve Replacement. As you all know the heart valves help to keep all of the blood moving in one direction through the heart. If valves are damaged in any way, and allow some blood to move backwards through them, it can lead to serious heart problems over time. There are many causes for these valve conditions. Some problems are congenital and people are born with defective valves, while others can be caused by bacterial infections, heart attacks, or atherosclerosis or calcification. If caught early enough, though, doctors can repair damaged heart valves, but in many cases surgeons may need to replace an entire diseased valve with an **artificial heart valve**. These valves generally have two types: **mechanical and biological**. **Mechanical valves** are typically made out of a hard, strong material and look like a one way trap door. **Biological valves** are typically made from pig valves which are treated so that the human body will not react or destroy the valve upon implantation.



What can doctors do for a heart failure patient?

Left ventricular assist devices (LVADs). Some patients with heart failure cannot be managed with medications. These patients will need an **LVAD** to help them be able to pump blood to their body. An LVAD is a pump that gets implanted into the **apex of the left ventricle**; essentially, a hole (called a **plug**) is cut out of the apex, and the LVAD is inserted into this hole. The other end of the LVAD is attached by a tube to the aorta. Thus, blood from the left ventricle

can be pumped out to the aorta through the LVAD. These devices are often used to assist the patient until they can receive a heart transplant (sometimes referred to as a **bridge to transplantation**).



Heart Transplant. Usually, the final option for patients with heart failure who are very sick is to receive a **heart transplant**. In this procedure doctors find an organ donor, typically a person who is brain dead but whose organs are still healthy and functional, remove the patient's heart, and then quickly implant the donor heart into the patient (**recipient**) by reconnecting all

of the vessels to one another. After this procedure, the new donor heart will immediately begin to function, even though it is in a different body. While this procedure helps many people, it is not a perfect solution. One problem is that **the recipient's body will recognize the new heart as foreign** and try to attack it. This is similar to how your own body attacks and destroys foreign germs. This **immune response** has to be impeded or the new heart will become damaged. Therefore, patients who have heart transplants have to take various **immune suppressing drugs**. Another problem is that while there are many people who need heart transplants, there are not enough donor hearts for everyone who needs one. Therefore, there is a **national list of potential transplant recipients**, which allows patients to sign up and wait for a heart to become available. This also allows for a fair and equitable system for organ donation, with the sickest patients and best donation candidates getting priority.