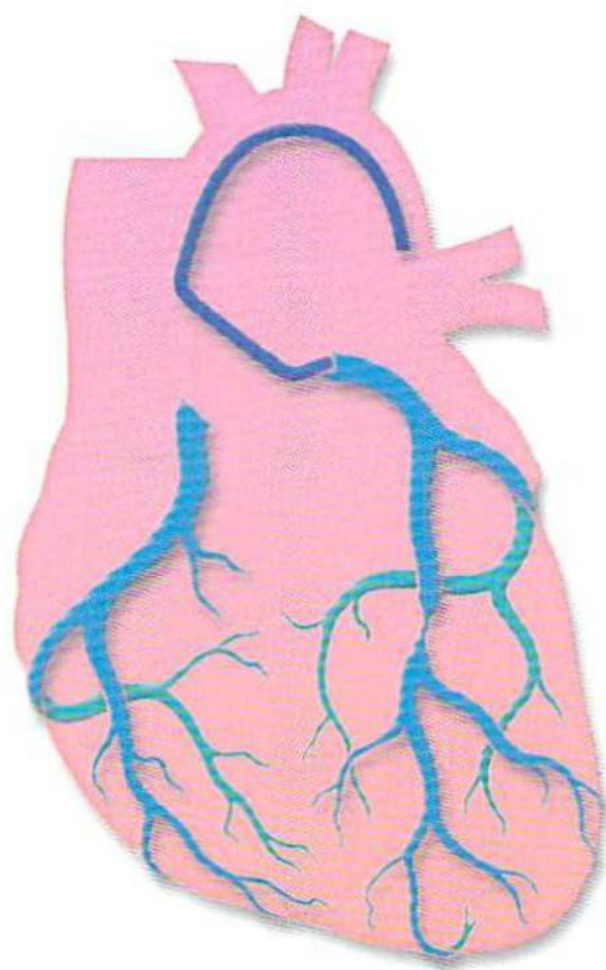
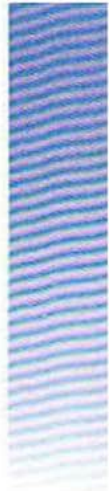


Cardiac Catheterization



A Patient's Guide

This booklet is not intended to replace professional medical care. Only your doctor can diagnose and treat medical problems.



Your doctor has recommended cardiac catheterization to find out what is causing your heart problem. Now, you probably have questions and concerns about the procedure. This booklet can help answer many of your questions.

What Is Cardiac Catheterization?

During cardiac catheterization, doctors insert a long, thin, flexible tube, called a **catheter**, into the body. The catheter is inserted into a blood vessel and is guided toward the heart.

The procedure allows doctors to study how well your heart pumps blood and to examine the coronary arteries (the vessels that supply blood to the heart muscle) and the heart valves.

Other terms used to describe cardiac catheterization include coronary angiography, angiogram, cardiac cath, and heart cath.

Why Is Catheterization Important?

Cardiac catheterization provides more accurate and detailed information about how well your heart is working than other diagnostic tests. It helps doctors diagnose your problem accurately, and it lets them choose the best treatment for you.

How the Heart Works

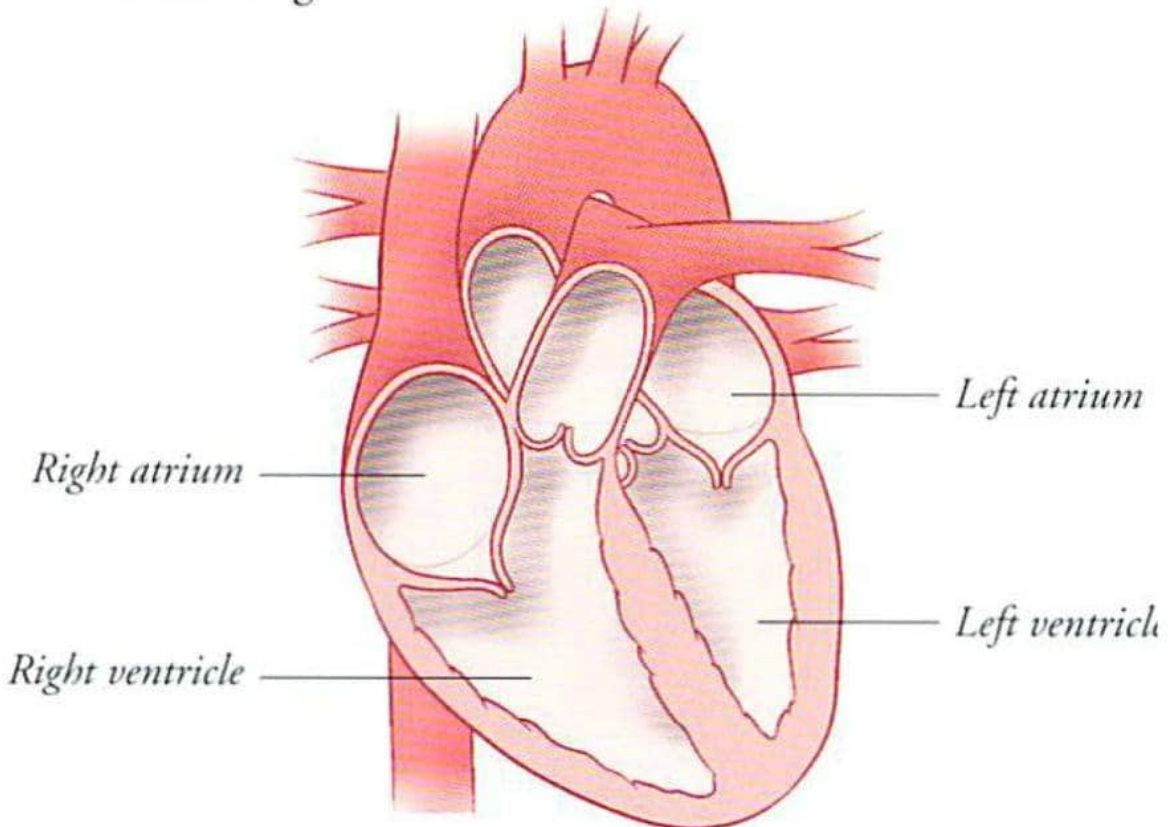
Before discussing cardiac catheterization, it helps to understand how the heart works.

The Heart as a Pump

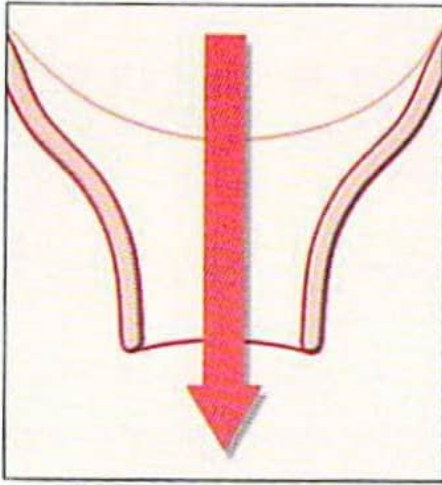
The heart is a hollow organ that constantly pumps blood throughout the body. It is made of strong muscle tissue, called **heart muscle** (myocardium).

The heart has four chambers: two chambers on the left side and two on the right. The upper chamber on each side, called an **atrium**, receives and collects blood. The lower chamber on each side, called a **ventricle**, pumps blood out of the heart.

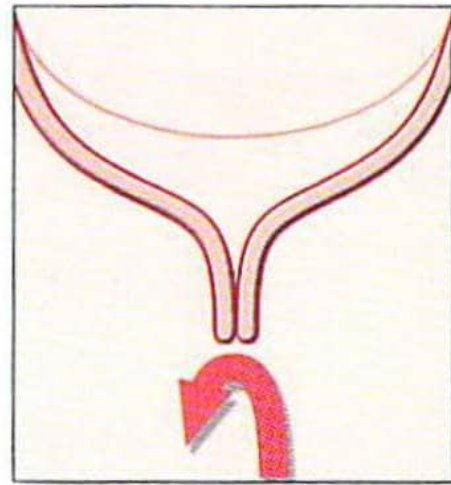
The left ventricle is the main pumping chamber of the heart. It pumps blood to all parts of the body except the lungs. The right ventricle pumps blood to the lungs.



Four **heart valves** direct the flow of blood within the heart. The valves act like one-way doors, allowing blood to move forward and preventing it from backing up into the chamber from which it came.



Valve is open



Valve is closed

As it beats, the heart pumps blood through a system of blood vessels. These are elastic-like tubes that carry blood to every part of the body. Blood leaves the heart in **arteries** and returns to it in **veins**.

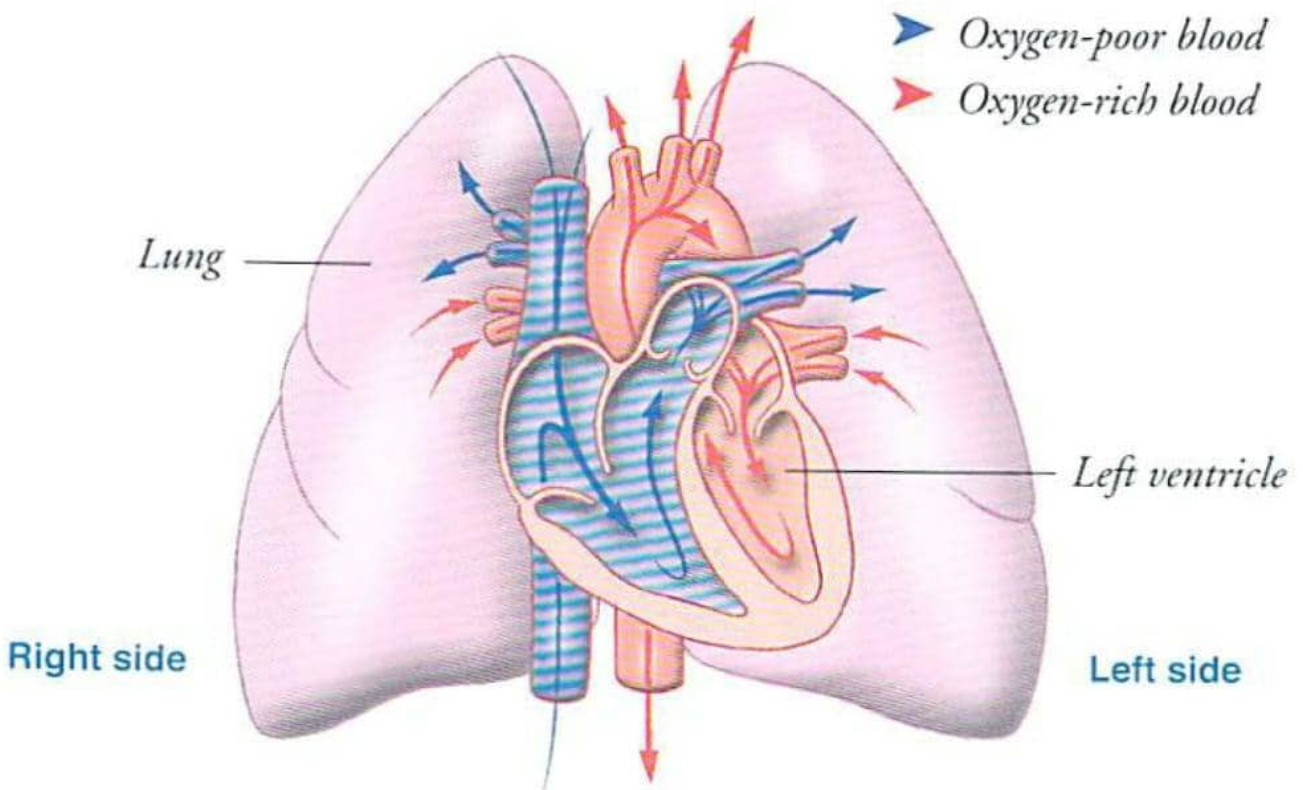
The heart pumps blood into the arteries with enough force to keep the blood flowing. **Blood pressure** is the amount of tension (force) that blood exerts on the walls of the arteries as the heart beats.

How Blood Circulates

The four heart chambers work together to **contract** (squeeze) and pump blood. As it circulates, blood delivers oxygen and nutrients throughout the body.

Blood that returns from the body is low in oxygen. This *oxygen-poor blood* collects in the right atrium and then flows into the right ventricle. The blood is then pumped to the lungs, where it is enriched with oxygen.

This *oxygen-rich blood* re-enters the heart at the left atrium, then flows into the left ventricle, the heart's main pumping chamber. Next, the blood is pumped into arteries that carry it to all parts of the body.



The heart, lungs, and circulation

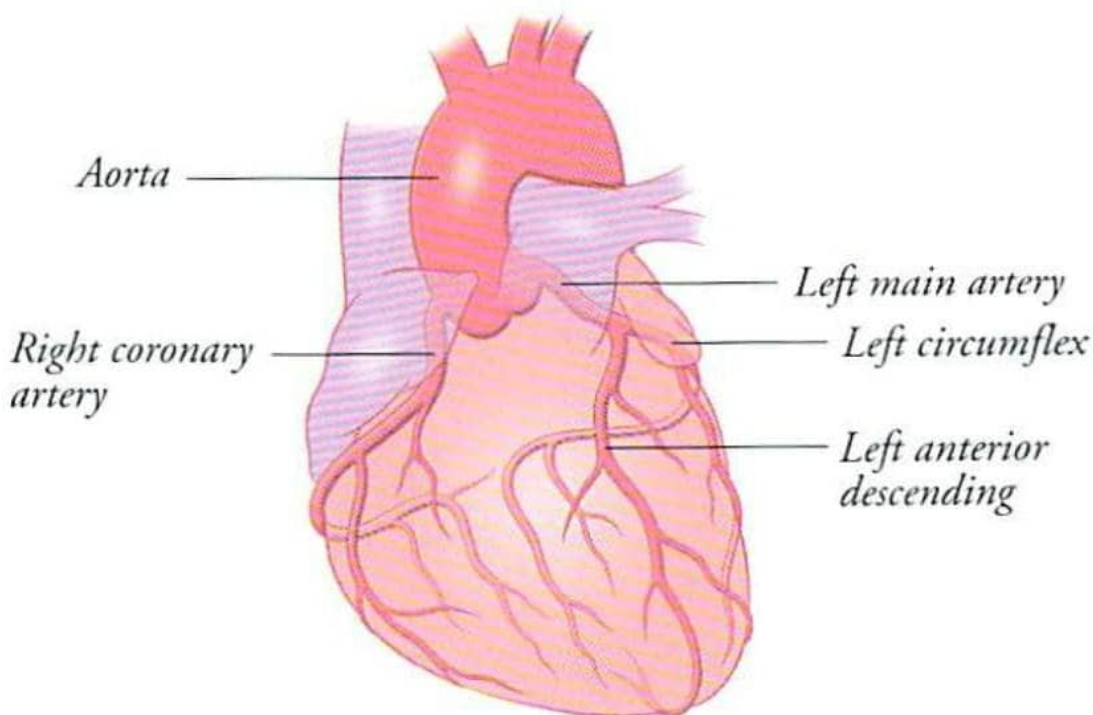
The Coronary Arteries

In order to keep pumping blood day after day, the heart needs its own supply of oxygen. The coronary arteries are the vessels that carry oxygen-rich blood to the heart muscle.

As blood leaves the left ventricle, it is pumped into the **aorta**, the body's main artery. The two main coronary arteries (called the "left" and "right") start at the beginning of the aorta, near the top of the heart.

The left main artery branches into two arteries: the left anterior descending and the left circumflex. They supply blood mostly to the front and left side of the heart. The right coronary artery supplies blood to the right side and back of the heart.

The coronary arteries travel on the outer surface of the heart and divide into smaller branches. These branches then penetrate deep into the heart muscle, carrying oxygen-rich blood to all the cells.

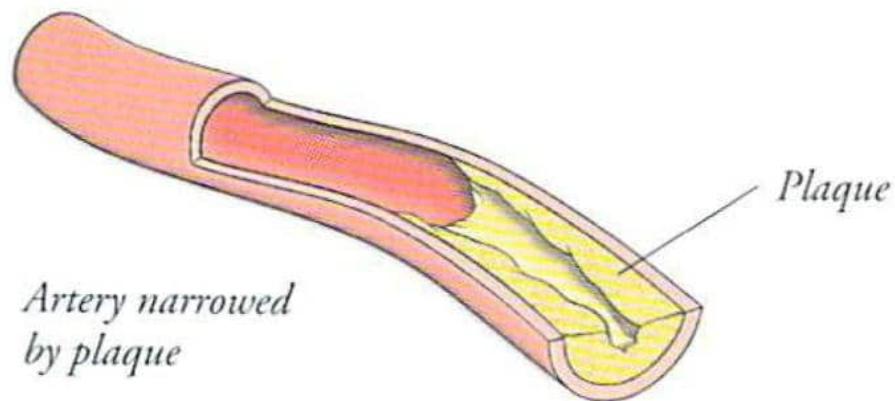


When Is Catheterization Needed?

Cardiac catheterization allows doctors to diagnose a number of heart conditions, such as coronary heart disease, heart valve disease, congenital heart defects, and heart muscle disease.

■ *Coronary Heart Disease*


The inside walls of your arteries are normally smooth and flexible, which allows blood to flow through them easily. Over the years, fatty deposits may build up on the inside of an artery's wall.



As these fatty deposits, called **plaque**, continue to build up, they narrow the artery and can reduce or even block the flow of blood.

When plaque builds up in the coronary arteries, the result is **coronary heart disease**. Blood flow in the coronary arteries may be reduced enough to cause angina or heart attack.

Angina is pain or discomfort in the chest, arm, or jaw that occurs when not enough blood flows to the heart muscle. It typically occurs during physical exertion or emotional stress, when the heart works harder and needs more oxygen.



A **heart attack** (myocardial infarction) occurs when a coronary artery becomes totally blocked, usually by a blood clot. This cuts off the blood supply to an area of the heart muscle and causes that part of the heart muscle to die.

Following a heart attack, the damaged heart may not pump as well as a normal heart. This may lead to **heart failure**. In heart failure, fluid tends to build up in the lungs and other parts of the body. Common symptoms of heart failure include shortness of breath, swelling of the feet and legs, and fatigue.

Heart failure can be caused by any medical condition that injures the heart or makes the heart work too hard for a long time. Common causes include a past heart attack, high blood pressure, heart muscle disease, and heart valve disease.

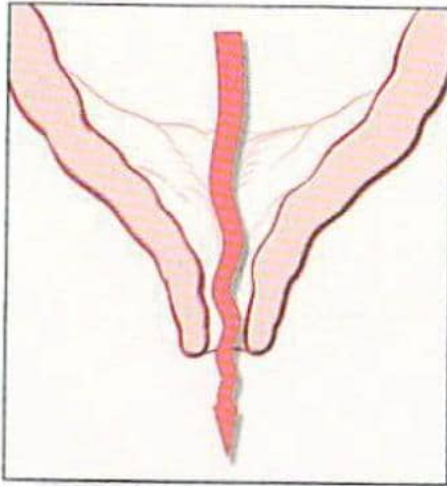
If your doctor suspects that you have coronary heart disease or heart failure, he or she may recommend that you have cardiac catheterization.

Certain conditions and habits, called **risk factors**, can increase the build-up of fatty deposits in your arteries. People who smoke cigarettes or have high blood cholesterol, for example, are more likely to have a heart attack than people without these risk factors. By changing your lifestyle, you can help control some of these risk factors (see page 30).

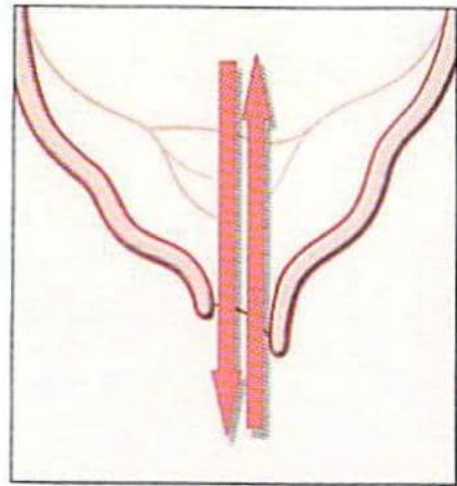
■ *Heart Valve Disease*

Heart valve disease occurs when a heart valve (see page 5) does not open or close properly.

- ▶ In **valvular stenosis**, the heart valve is narrowed. It may be thickened and/or stiff and does not open all the way. The heart has to work harder to push blood through a smaller opening.
- ▶ In **valvular regurgitation** (or insufficiency), the heart valve is leaky. It may be loose, shortened, or torn. As a result, the valve does not close tightly enough, and blood leaks backward. The heart has to work harder to pump some of the same blood through the valve again.



Valvular stenosis



Valvular regurgitation

Stenosis and regurgitation tend to get worse with time. They may cause the heart muscle to weaken, which can result in heart failure (see page 9).

Catheterization may be needed to confirm heart valve disease and to accurately measure how severely the valve is narrowed or leaking.

■ *Congenital Heart Defects*

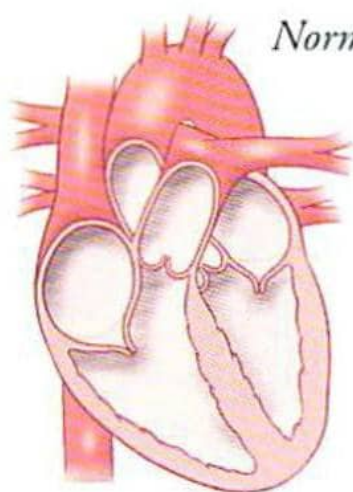
A congenital heart defect is a deformity of the heart that is present at birth. An abnormal hole between heart chambers or a narrowed valve are examples of congenital heart defects.

When a defect is severe enough, it is harder for the heart to pump blood. With time, the heart may weaken, and symptoms (such as shortness of breath and fainting spells) may develop.

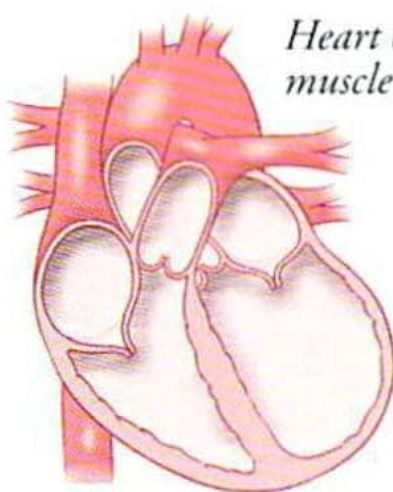
In some cases, cardiac catheterization may be needed to confirm a heart defect and/or to assess how severe the problem is.

■ *Heart Muscle Disease*

Heart muscle disease, or **cardiomyopathy**, refers to diseases that primarily affect the heart muscle. In its most common form, called dilated cardiomyopathy, the heart muscle weakens and the heart chambers enlarge. Cardiomyopathy can be caused by a variety of conditions, such as infection or alcohol abuse, or it can occur for an unknown reason.



Normal heart



Heart enlarged by heart muscle disease

Your Medical Evaluation

If your doctor thinks you may have heart disease, he or she will order one or more of these tests:

- An **electrocardiogram**, or **ECG**, is a simple test that records the electrical activity of your heart. The ECG can show new heart attacks, previously damaged heart muscle, enlarged heart chambers, thickened heart muscle, abnormal heart rhythms, and a few other heart conditions.
- An **exercise ECG test** (or stress test) is done while you walk on a treadmill or pedal a stationary bicycle. It allows doctors to learn how well your heart pumps when it is made to work harder. The exercise ECG test can help detect problems that may not show up on a resting ECG.
- An **echocardiogram** uses ultrasound waves to create an image of the heart and the pattern of blood flow through it. It is useful for measuring the size and strength of the heart. It can also help determine whether a valve is narrowed or leaking, and assess how severe the problem is.



- A **heart scan** (or thallium scan) uses a radioactive substance, called a tracer, to produce images of the heart muscle. In patients with coronary heart disease, the heart scan helps identify areas of the heart muscle that do not receive enough blood flow.

Why Do Cardiac Catheterization?

If these basic tests do not give your doctor all the information he or she needs, you may be a candidate for cardiac catheterization. This test provides the most accurate and detailed information about how your heart is working.

In general, cardiac catheterization is done for one or more of the following reasons:

- to evaluate or confirm coronary heart disease (for example, in patients with chest pain and/or an abnormal stress test)
- to determine whether treatment (with balloon angioplasty or bypass surgery) can help a patient diagnosed with coronary heart disease
- to see how well blood flows through the coronary arteries after angioplasty or bypass surgery
- after a heart attack, to find out how severely the coronary arteries are narrowed or blocked
- to evaluate the cause of heart failure
- to determine if there is significant heart valve disease that might require surgery
- to determine whether there is a congenital heart defect and evaluate how severe it is

Preparing for Catheterization

Unless you are already in the hospital, you will most likely be asked to arrive in the morning on the day of your catheterization.

You may have several routine tests, such as an ECG, x-rays, and blood tests. (These tests may be done a few days before the procedure.)

The doctor will review your medical history and examine you. (You may see the doctor at the office several days before the procedure.)

The doctor or nurse will talk with you about the procedure and its purpose, benefits, and risks. This is a good time to ask questions and, most important, to share any concerns you may have. You will then be asked to sign a consent form.

A nurse will shave and cleanse the area where the catheters will be inserted. This is usually at the groin (the fold between the thigh and abdomen). In some cases it may be at the wrist or arm. Shaving and cleansing make it easier to insert the catheters and help to prevent infection.

An intravenous (IV) line will be inserted into a vein in your arm. This line allows drugs to be injected directly into the vein, if they are needed. To help you relax, you will be given a sedative.

If you wear dentures, hearing aids, or glasses, you will most likely be allowed to keep them on.

Before Your Catheterization

- Generally, you'll be asked **not to eat or drink anything** for 6 to 8 hours before the procedure. This helps prevent nausea. You may have small sips of water to take your medications.
- Check with your doctor several days before the procedure. **You may be asked to stop some medications** (such as aspirin or anticoagulants) for a few days before your catheterization.
- **Make arrangements** with a friend or family member to drive you to and from the hospital. You will not be permitted to drive home after the procedure, since you may be sedated.
- **Pack a small bag** in case your doctor decides to keep you in the hospital overnight. You may want to include a robe, slippers, pajamas or nightgown, and toiletries.
- **Bring a list of the names and dosages of all the medications** you are taking.
- **Tell the doctor or nurse** if you have had any allergic reactions to medications or x-ray dye (contrast), iodine or seafood, or if you have a history of bleeding problems.
- For your comfort, **empty your bladder** as much as possible before the procedure begins. There will also be a bedpan or a urinal, should you need it during the procedure.

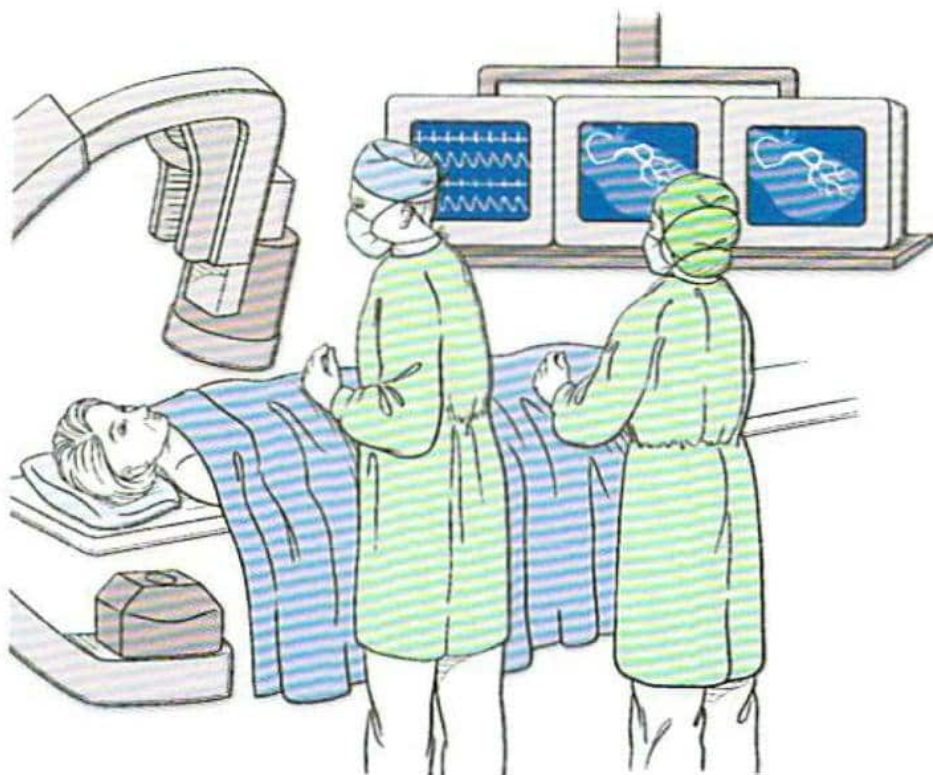
During Cardiac Catheterization

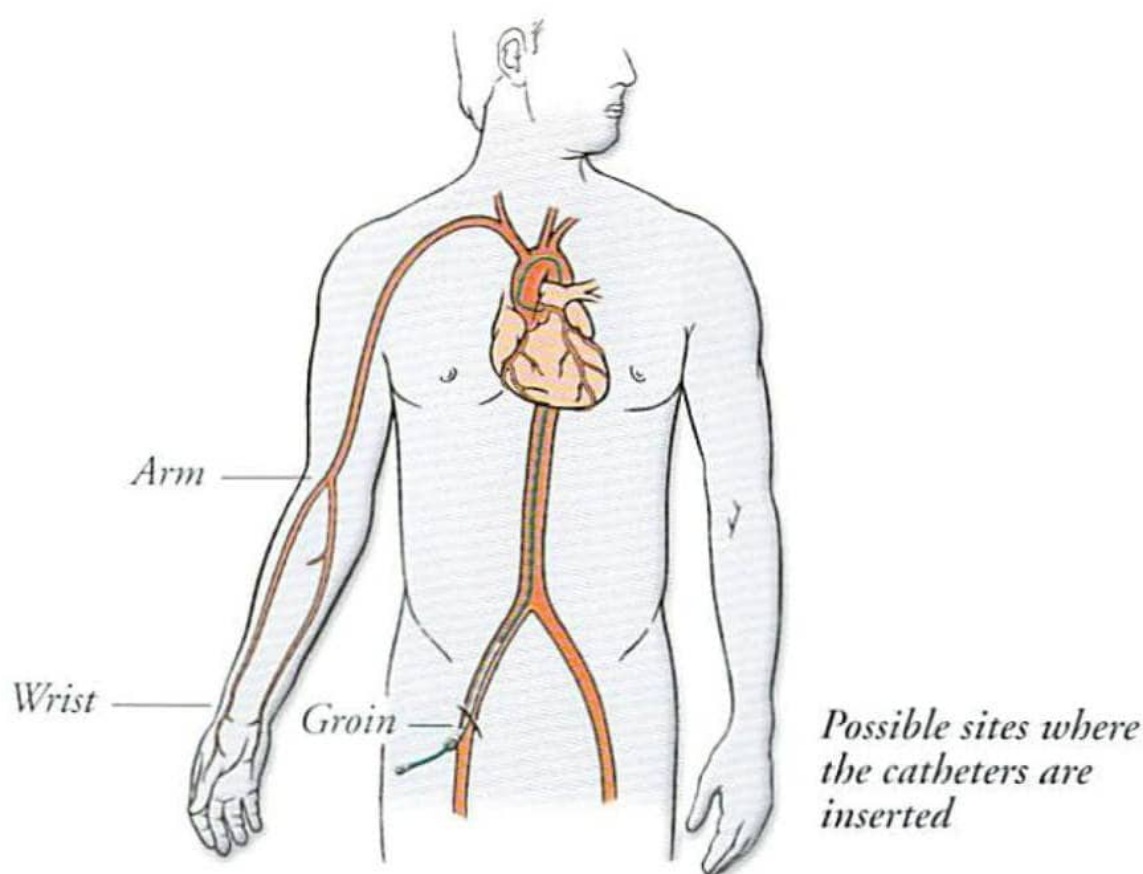
Cardiac catheterization is performed in a specially equipped x-ray room called a cardiac catheterization laboratory, or simply, **cath lab**.

You will be taken to the cath lab in a wheelchair or on a movable bed. Then you will be helped onto an x-ray table. The table has a large x-ray camera above it and television screens close by. There also are heart monitors and other instruments.

The cath lab team generally includes a cardiologist, an assistant, nurses, and technologists.

Once you are positioned on the x-ray table, you will be connected to several monitors and then covered with sterile sheets. The staff will be wearing sterile gowns, gloves, and possibly masks.





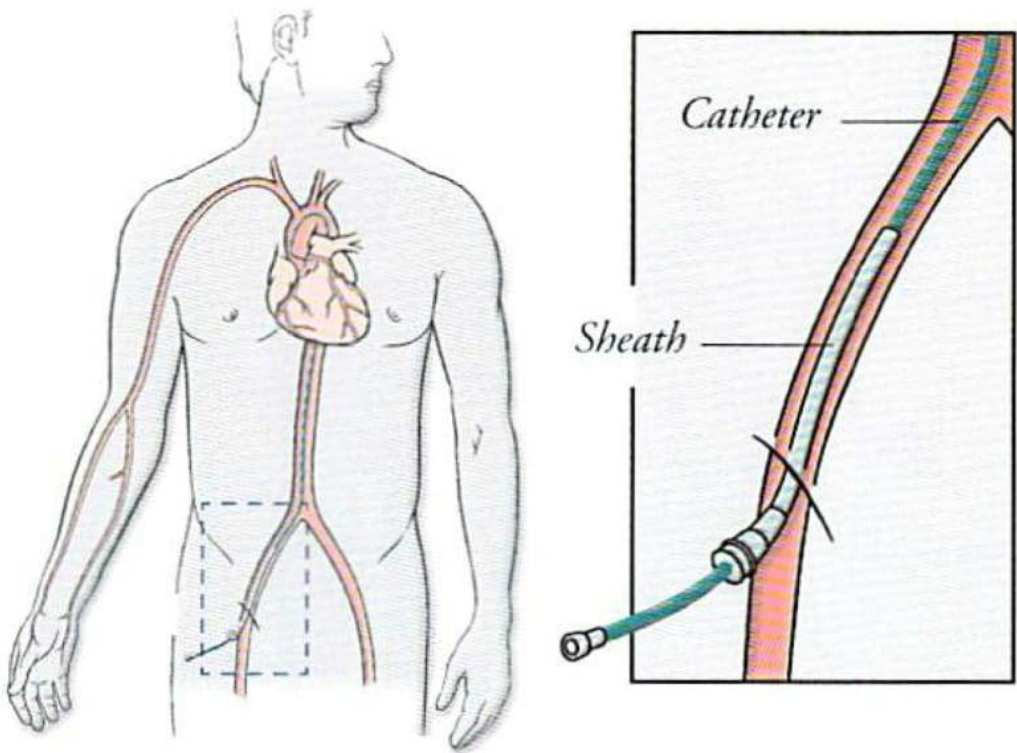
What Happens During the Procedure?

The site where the catheters will be inserted is usually in the groin. Sometimes it is in the wrist or arm.

The site is cleansed thoroughly. A local anesthetic is injected into the skin with a tiny needle to numb the area. This may cause a stinging sensation.

A small incision is made in the skin, and a needle is used to puncture the blood vessel (usually an artery). A guidewire (a soft and flexible wire) is threaded into the artery. A short plastic tube, called a **sheath**, is then slipped over the guidewire and into the artery. The guidewire is then removed.

Once the sheath is in place, doctors can insert and remove several different catheters without having to use a needle each time.



The catheter is inserted into the artery and guided toward the heart, while the staff watches its progress on a television screen. The catheter may be removed and replaced several times. This is done to reach each of the heart chambers or coronary arteries.

Once the catheter is inside the heart, the doctors can measure the pressures in the left ventricle (the main pumping chamber) and take pictures of the coronary arteries and left ventricle.

If you are also having a **right-heart catheterization**, a special catheter is inserted into a *vein* and is guided to the right side of the heart. This is usually done to measure the pressures inside the right heart chambers and in the lungs, especially in people who have a weakened heart.



What You Can Expect

You will be given medication to help you relax and make you drowsy. You may be awake, or you may sleep through part or all of the procedure. The staff will be monitoring you at all times.

You may be asked to take a deep breath and hold it, to keep the pictures from blurring. You may also be asked to cough forcefully several times, to help move the dye through the heart.

The procedure generally is not painful, although you may feel some pressure as the catheters are inserted. You will not feel the catheters as they move through the blood vessels and into your heart. For many, the most difficult part of the procedure is having to lie still for a long time on a hard table.

As x-ray contrast is injected into the heart, you may feel a warm sensation (“hot flash”) through your body, lasting for 20 to 30 seconds. You may also feel nausea, chest discomfort, or a mild headache.

A complete cardiac catheterization procedure usually takes from one to two hours. If you feel pain or discomfort at any time during the procedure, let the staff know.

What Does Catheterization Show?

Cardiac catheterization allows doctors to measure the pressures inside the heart, study how well the heart is pumping blood, and take pictures of the coronary arteries and the heart chambers.

■ *Measuring the Pressures*

Blood within the heart or vessels exerts pressure (see page 5). As a heart chamber contracts and pumps blood, it creates **pressure waves**. These pressure waves are transmitted through the catheter, displayed on monitor screens, and recorded on tracing paper.



A tracing showing pressure waves in an artery.

As part of the catheterization procedure, doctors measure the **cardiac output**. This is the amount of blood pumped by the heart each minute. Knowing the cardiac output tells doctors how well the heart is pumping blood.

In patients with a narrowed heart valve (stenosis, see page 10), the pressures on both sides of the diseased valve are measured. The greater the difference of pressures (called **pressure gradient**), the more severe the valve's narrowing is.

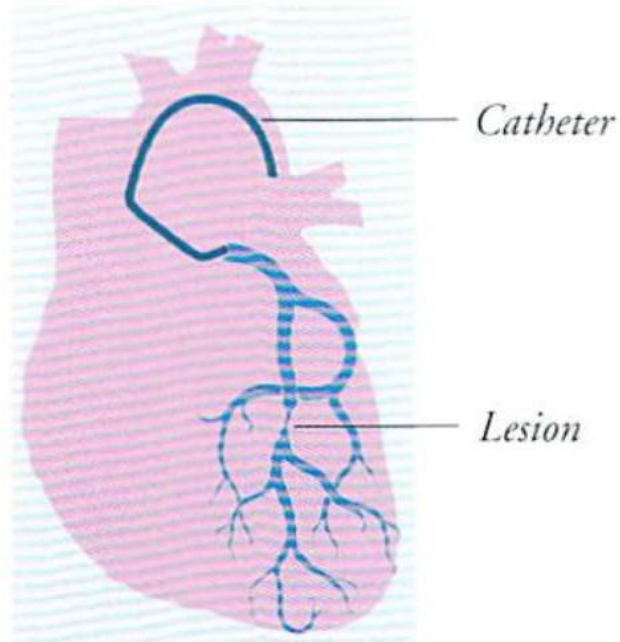
■ *Coronary Angiography*

During coronary angiography, x-ray dye, or **contrast**, is injected through the catheter into the coronary arteries. As the contrast fills the arteries, they can be clearly seen on x-rays. The resulting pictures, called **angiograms**, can be recorded and stored.

A normal coronary artery has smooth walls and tapers down (gets smaller) gradually. A diseased artery may show an abnormal narrowing, called a “**lesion**.” Other times, the artery may be completely blocked. Multiple “views” are taken, at different angles, to better show the lesions or blockages in the arteries.

Coronary angiography

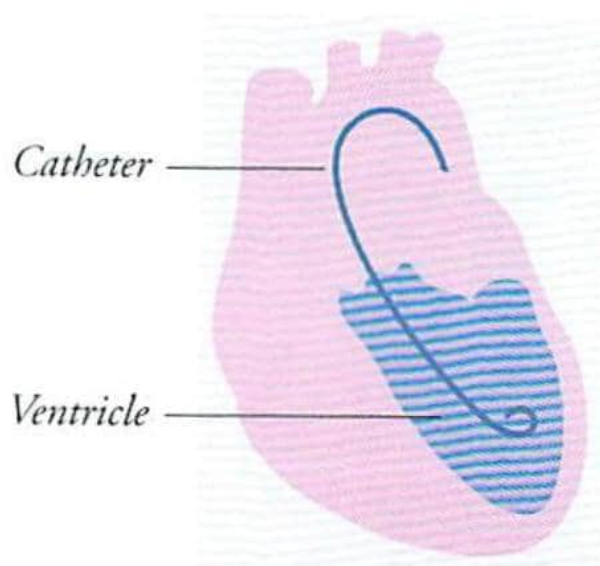
Contrast is injected through the catheter into the left coronary artery. As the artery fills with contrast, it can be viewed on the television screen. Here, a lesion can be seen in the left anterior descending coronary artery.



Doctors can estimate how severe the problem is based on how narrow a lesion is, where it is located, and how many arteries are diseased. In general, lesions that are closer to the beginning of an artery are more serious.

■ *Left Ventriculography*

During left ventriculography, x-ray contrast is injected through a special catheter into the left ventricle, the main pumping chamber. The resulting pictures show the ventricle as it contracts and pumps blood.



Left ventriculography

Contrast is injected through a special catheter into the left ventricle. The ventricle's pumping action can be viewed on the television screen and recorded.

Normally, all areas of the ventricle contract forcefully. If a particular area does not contract as well as it should, it may not be receiving enough blood because of a narrowed or blocked coronary artery.

The **ejection fraction** is a commonly used measure of your heart's pumping strength. It is the percentage of blood that is pumped out of the left ventricle with each heartbeat. A normal ejection fraction is greater than 55 percent. Patients with heart failure often have an ejection fraction of less than 40 percent.

In patients with a leaky heart valve (regurgitation, see page 10), the x-ray contrast can be seen flowing back in the "wrong" direction.

Is Catheterization Safe?

Because one or more catheters are inserted into your body, catheterization does have some risk. The risk is small, however, and the test is generally safe.

Most of the complications, if they occur, are minor and temporary. These include nausea and vomiting, allergic skin rash (hives), and irregular heartbeat.

Some people may have bleeding at the insertion site. Blood collects under the skin and causes swelling and/or bruising in the groin or arm.

More serious complications are rare. These include damage to the heart and blood vessels, blood clots, infection, allergic reactions to the contrast, abnormal heart rhythms, damage to the kidneys from the contrast, heart attack, or stroke. Death is very rare.

Most patients who have catheterization do not have serious complications. However, you should be aware of the risk involved. If you have any questions about your own risk, ask your doctor.

Potential Benefits

Cardiac catheterization provides more accurate and detailed information about how your heart is working than other diagnostic tests. This information helps doctors diagnose your problem accurately and allows them to choose the most effective treatment.

After Your Catheterization

After the catheters are removed, the doctor or nurse applies firm pressure to the insertion site for 10 to 20 minutes, to keep the site from bleeding. In some cases, doctors use a *compression device* (“clamp”) to apply pressure to the site. Other times, they may use a *vascular closure device* to seal off the small hole left in the artery after the procedure.

You will then be taken to a recovery area or to your room. You will be encouraged to drink liquids to help flush the contrast out of your body.

If the catheters were inserted in your groin, you will need to lie flat on your back for 2 to 6 hours, so that the site can begin to heal properly. During that time, do not bend or lift your leg. To relieve stiffness, you may move your foot or wiggle your toes.

(If the catheters were inserted in your wrist or arm, or if a vascular closure device was used, you will be permitted to get out of bed sooner.)

The nurse will check your pulse and blood pressure often, and will also check the insertion site for bleeding. If you feel sudden pain at the site or if you notice bleeding, let the nurse know right away.

The doctor who performed the procedure may give you some preliminary results soon after the test is over. However, a thorough, detailed analysis of all the findings will take more time.

Most patients go home the same day. Some patients may need to stay for more tests or treatments. When it is time to go home, have a family member or a friend drive you.

At Home, After the Procedure

- **Limit your activity** during the first couple of days at home. You can move about, but do not strain or lift heavy objects.
- **Leave the dressing** on your groin (or arm) until the day after the procedure. The nurse will tell you how to take it off and when it is OK to take a shower.
- **A bruise or a small lump** under the skin at the catheter insertion site is quite common. It should disappear within a few weeks.
- **Call your doctor** if the insertion site begins to bleed, the bruising or swelling increases, or the leg (or arm) where the catheters were inserted feels cold or numb.
- **Call your doctor or nurse** if the insertion site becomes painful or warm to the touch, or you develop a temperature over 100°F.
- **Ask your doctor** when you can return to your normal activities, and whether there are things you should not do.
- **Be sure to check with your doctor or nurse about medications**—which ones to keep taking and which ones to stop.

Treatment Options

The treatment your doctor recommends will depend on the type of heart problem you have, how severe your symptoms are, and what the catheterization and other tests show.

If your problem is not too serious, your doctor may simply adjust your medications. Or, he or she may recommend balloon angioplasty or a stent to open a narrowed artery. Less often, heart surgery may be advised to create bypasses around blocked arteries or to correct defective heart valves.

In some cases, doctors may decide to proceed with balloon angioplasty immediately following the catheterization. This possibility will be discussed with you before the procedure.

■ *Medications*

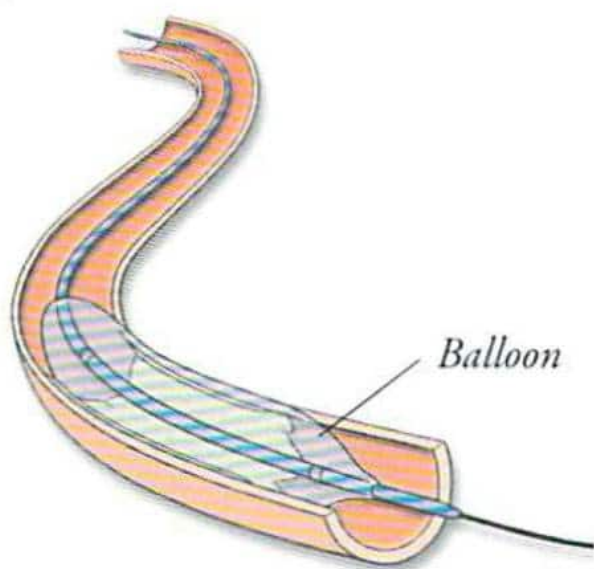
Many medications are available to treat heart disease. Although medications do not “cure” the problem (such as blockages in the arteries or defective valves), they usually reduce symptoms and can help improve the quality of life in patients with heart disease.



■ *Balloon Angioplasty*

Balloon angioplasty is a procedure that allows doctors to open narrowed coronary arteries without surgery. It relieves symptoms of heart disease by improving the flow of blood to the heart muscle.

During angioplasty, a catheter with a small balloon at the tip is guided into the diseased artery. When the catheter reaches the narrowed area, the balloon is inflated. This flattens the plaque against the artery's wall. The balloon is then deflated and removed. The larger opening in the artery allows more blood to flow through.

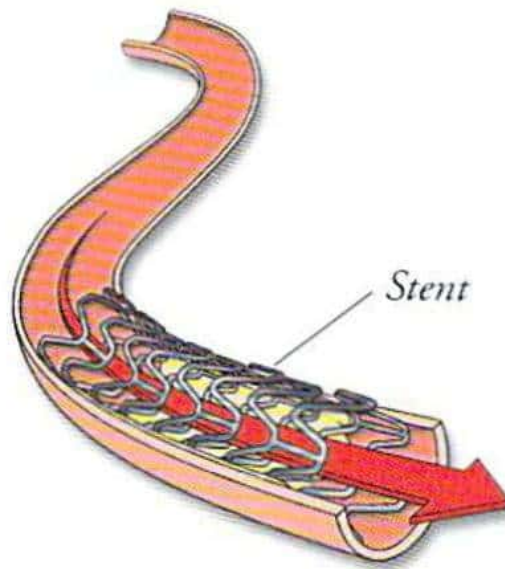


In about one-third of balloon angioplasty procedures, the artery may narrow again. This problem is called **restenosis**. Restenosis is caused by the growth of new tissue that replaces injured tissue at the site where the artery was widened. To help prevent restenosis, doctors often insert a coronary stent (see next page).

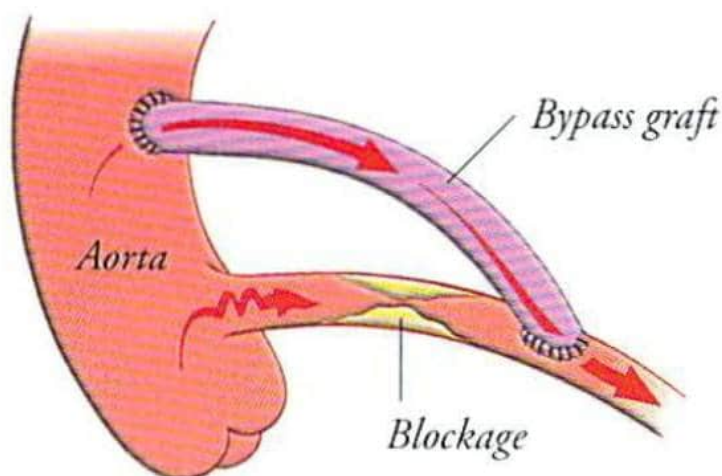
■ *Coronary Stents*

To help prevent the coronary artery from closing off after balloon angioplasty and to reduce the chance of restenosis, doctors often implant a coronary stent.

A stent is a small device that is placed in an artery to help keep it open. It may look like a small metal coil, a slotted tube, or a mesh. It acts like a tiny metal scaffold that supports the artery's walls.



If a stent is needed, it is usually implanted right after angioplasty. The stent is mounted on a balloon catheter and threaded into the diseased artery. When the balloon is inflated, the stent expands and presses against the inside wall of the artery. The balloon is then deflated and removed. The stent will remain in place permanently, helping to keep the artery open.



■ *Heart Surgery*

The two most common types of heart surgery are coronary bypass surgery and valve surgery.

During **coronary bypass surgery**, surgeons use a graft—a blood vessel from the leg or chest—to create a detour (bypass) around the narrowed or blocked artery. One end of the graft is attached to the aorta, and the other end is sewn to the artery, beyond the diseased area. This allows blood to flow freely from the aorta to the heart muscle.

During **valve surgery**, surgeons replace the defective valve with an artificial one. In some cases, if the valve is not too deformed, they may repair the valve instead of replacing it.

■ *Changes in Your Lifestyle*

No matter which treatment your doctor recommends, it is important that you make some changes in your lifestyle. This will help control certain risk factors (such as smoking, high blood cholesterol, and high blood pressure) that can cause fatty deposits (plaque) to build up in your arteries.

- If you smoke—quit!
- Enjoy foods that are low in fat and cholesterol.
- Lose excess weight, and keep it off.
- Exercise regularly (consult your doctor before starting an exercise program).
- Keep your blood pressure under control.
- Take your medications as directed.

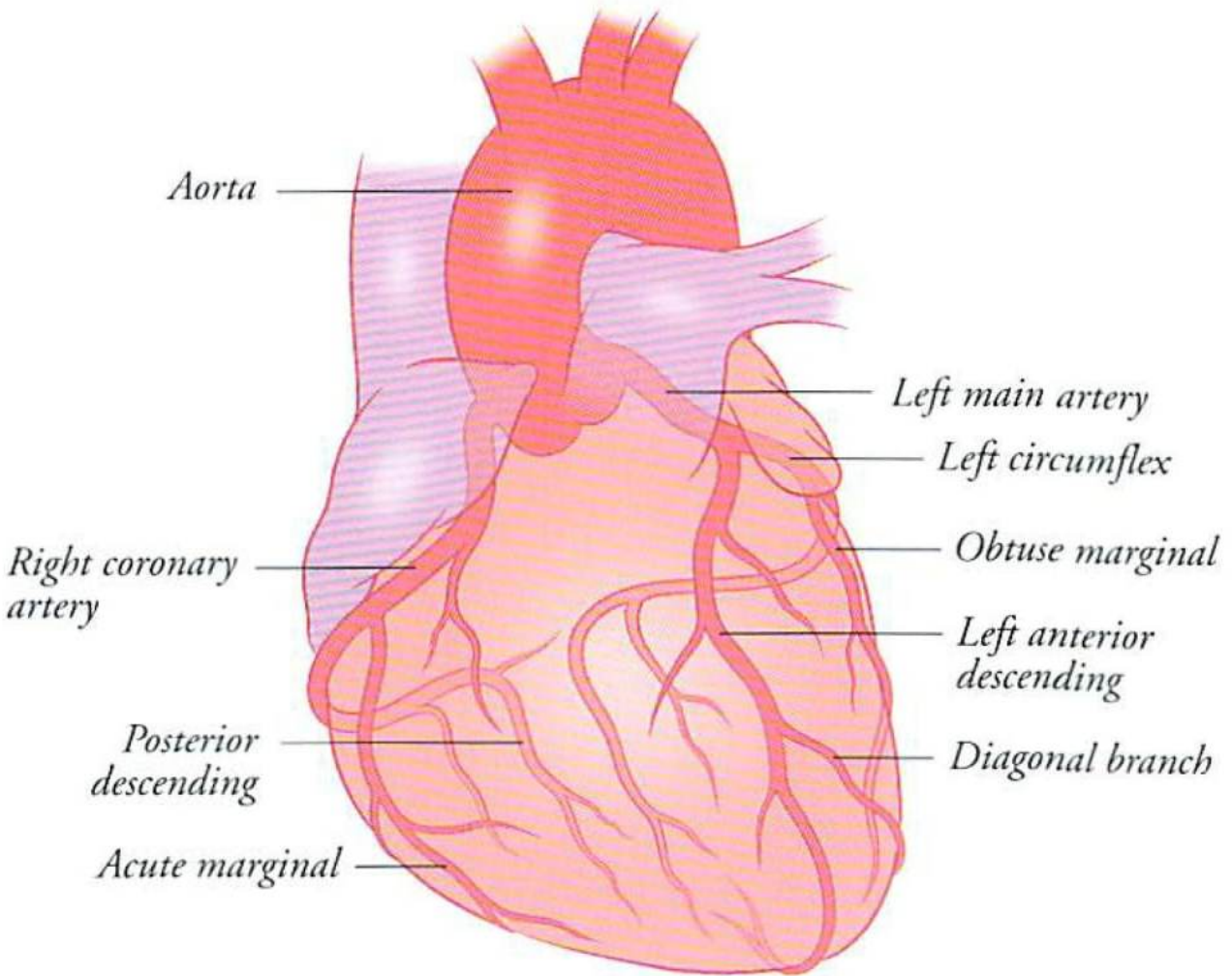
Ask your doctor to give you guidelines or refer you to programs to help you eat a heart-healthy diet, lose weight, start an exercise program, or stop smoking.

.....

Making these changes in your lifestyle and following your doctor's instructions are essential for getting the most long-term benefit from whatever treatment your doctor recommends.

Diagram of the Coronary Arteries

Below is a diagram of the coronary arteries. Your doctor can use this chart to mark where the lesions or blockages in your coronary arteries are.



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