

Atherosclerosis and Coronary Artery Disease

Coronary artery disease is thought to begin with damage or injury to the inner layer of a coronary artery, sometimes as early as childhood. The damage may be caused by various factors, including:

- Smoking
- High blood pressure
- High cholesterol
- Diabetes
- Radiation therapy to the chest, as used for certain types of cancer

Once the inner wall of an artery is damaged, fatty deposits (plaques) made of cholesterol and other cellular waste products tend to accumulate at the site of injury in a process called atherosclerosis. If the surface of these plaques breaks or ruptures, blood cells called platelets will clump at the site to try to repair the artery; this clump can block the artery, leading to a heart attack.

Risk factors

Risk factors for coronary artery disease include:

- **Age.** Simply getting older increases your risk of damaged and narrowed arteries.
- **Sex.** Men are generally at greater risk of coronary artery disease. However, the risk for women increases after menopause.
- **Family history.** A family history of heart disease is associated with a higher risk of coronary artery disease, especially if a close relative developed heart disease at an early age. Your risk is highest if your father or a brother was diagnosed with heart disease before age 55, or your mother or a sister developed it before age 65.
- **Smoking.** Nicotine constricts your blood vessels, and carbon monoxide can damage their inner lining, making them more susceptible to atherosclerosis. The incidence of heart attack in women who smoke at least 20 cigarettes a day is six times that of women who've never smoked. For men who smoke, the incidence is triple that of nonsmokers.
- **High blood pressure.** Uncontrolled high blood pressure can result in hardening and thickening of your arteries, narrowing the channel through which blood can flow.
- **High blood cholesterol levels.** High levels of cholesterol in your blood can increase the risk of formation of plaques and atherosclerosis. High cholesterol can be caused by a high



level of low-density lipoprotein (LDL), known as "bad" cholesterol. A low level of

high-density lipoprotein (HDL), known as "good" cholesterol, also can promote atherosclerosis.

- **Diabetes.** Diabetes is associated with an increased risk of coronary artery disease. Both conditions share similar risk factors, such as obesity and high blood pressure.
- **Obesity.** Excess weight typically worsens other risk factors.
- **Physical inactivity.** Lack of exercise also is associated with coronary artery disease and some of its risk factors, as well.
- **High stress.** Unrelieved stress in your life may damage your arteries as well as worsen other risk factors for coronary artery disease.

Risk factors often occur in clusters and may build on one another, such as obesity leading to diabetes and high blood pressure. When grouped together, certain risk factors put you at an ever greater risk of coronary artery disease. For example, metabolic syndrome — a cluster of conditions that includes elevated blood pressure, high triglycerides, elevated insulin levels and excess body fat around the waist — increases the risk of coronary artery disease.

Sometimes coronary artery disease develops without any classic risk factors. Researchers are studying other possible factors, including:

- **Sleep apnea.** This disorder causes you to repeatedly stop and start breathing while you're sleeping. Sudden drops in blood oxygen levels that occur during sleep apnea increase blood pressure and strain the cardiovascular system, possibly leading to coronary artery disease.
- **C-reactive protein.** C-reactive protein (CRP) is a normal protein that appears in higher amounts when there's swelling somewhere in your body. High CRP levels may be a risk factor for heart disease. It's thought that as coronary arteries narrow, you'll have more CRP in your blood.
- **Homocysteine.** Homocysteine is an amino acid your body uses to make protein and to build and maintain tissue. But excessive levels of homocysteine may increase your risk of coronary artery disease and other cardiovascular CRP conditions.
- **Fibrinogen.** Fibrinogen is a protein in your blood that plays a central role in blood clotting. But too much may increase clumping of platelets, the type of blood cell largely responsible for clotting. That can cause a clot to form in an artery, leading to a heart attack or stroke. Fibrinogen may also be an indicator of the inflammation that accompanies atherosclerosis.
- **Lipoprotein (a).** This substance forms when a low-density lipoprotein (LDL) particle attaches to a specific protein. Lipoprotein (a) may disrupt your body's ability to dissolve



blood clots. High levels of lipoprotein (a) may be associated with an increased risk of cardiovascular disease, including coronary artery disease and heart attack.

Complications

Coronary artery disease can lead to:

- **Chest pain (angina).** When your coronary arteries narrow, your heart may not receive enough blood when demand is greatest — particularly during physical activity. This can cause chest pain (angina) or shortness of breath.
- **Heart attack.** If a cholesterol plaque ruptures and a blood clot forms, complete blockage of your heart artery may trigger a heart attack. The lack of blood flow to your heart may damage to your heart muscle. The amount of damage depends in part on how quickly you receive treatment.
- **Heart failure.** If some areas of your heart are chronically deprived of oxygen and nutrients because of reduced blood flow, or if your heart has been damaged by a heart attack, your heart may become too weak to pump enough blood to meet your body's needs. This condition is known as heart failure.
- **Abnormal heart rhythm (arrhythmia).** Inadequate blood supply to the heart or damage to heart tissue can interfere with your heart's electrical impulses, causing abnormal heart rhythms.

If you have too many cholesterol particles in your blood, cholesterol may accumulate on your artery walls. Eventually, deposits called plaques may form. The deposits may narrow or block your arteries. These plaques can also burst, causing a blood clot.

Coronary artery disease develops when your coronary arteries — the major blood vessels that supply your heart with blood, oxygen and nutrients — become damaged or diseased. Cholesterol-containing deposits (plaques) on your arteries are usually to blame for coronary artery disease.

When plaques build up, they narrow your coronary arteries, causing your heart to receive less blood. Eventually, diminished blood flow may cause chest pain (angina), shortness of breath or other coronary artery disease symptoms. A complete blockage can cause a heart attack.

Because coronary artery disease often develops over decades, it can go virtually unnoticed until it produces a heart attack. But there's plenty you can do to prevent and treat coronary artery disease. Start by committing to a healthy lifestyle.



Symptoms

If your coronary arteries become narrowed, they can't supply enough oxygenated blood to your heart — especially when it's beating hard, such as during physical activity. At first, the restricted blood flow may not cause any coronary artery disease symptoms. As the plaques continue to accumulate in your coronary arteries, however, you may develop coronary artery disease symptoms, including:

- **Chest pain (angina).** You may feel pressure or tightness in your chest, as if someone were standing on your chest. The pain, referred to as angina, is usually triggered by physical or emotional stress. It typically goes away within minutes after stopping the stressful activity. In some people, especially women, this pain may be fleeting or sharp and noticed in the abdomen, back or arm.
- **Shortness of breath.** If your heart can't pump enough blood to meet your body's needs, you may develop shortness of breath or extreme fatigue with exertion.
- **Heart attack.** If a coronary artery becomes completely blocked, you may have a heart attack. The classic signs and symptoms of a heart attack include crushing pressure in your chest and pain in your shoulder or arm, sometimes with shortness of breath and sweating. Women are somewhat more likely than men are to experience less typical signs and symptoms of a heart attack, including nausea and back or jaw pain. Sometimes a heart attack occurs without any apparent signs or symptoms.

When to see a doctor

If you suspect you're having a heart attack, immediately call 911 or your local emergency number. If you don't have access to emergency medical services, have someone drive you to the nearest hospital. Drive yourself only as a last resort.

If you have risk factors for coronary artery disease — such as high blood pressure, high cholesterol, diabetes or obesity — talk to your doctor. He or she may want to test you for the condition, especially if you have signs or symptoms of narrowed arteries. Even if you don't have evidence of coronary artery disease, your doctor may recommend aggressive treatment of your risk factors. Early diagnosis and treatment may stop progression of coronary artery disease and help prevent a heart attack.



Prevention and Follow up Recommendations for CAD

Preparing for your appointment

Early-stage coronary artery disease often produces no symptoms, so you may not discover you're at risk of the condition until a routine checkup reveals you have high cholesterol or high blood pressure. So it's important to have regular checkups.

If you're seeing your doctor because you're having symptoms or you have risk factors for coronary artery disease, you're likely to start by first seeing your primary care doctor or a general practitioner. Eventually, however, you may be referred to a heart specialist (cardiologist).

Because appointments can be brief, and because there's often a lot of ground to cover, it's a good idea to be prepared for your appointment. Here's some information to help you get ready for your appointment, and what to expect from your doctor.

What you can do

- **Be aware of any pre-appointment restrictions.** At the time you make the appointment, be sure to ask if there's anything you need to do in advance, such as restrict your diet. For a cholesterol test, for example, you may need to fast for a period of time beforehand.
- **Write down any symptoms you're experiencing,** including any that may seem unrelated to coronary artery disease.
- **Write down your key medical information,** including other conditions with which you've been diagnosed, all medications and supplements you're taking, and any family history of heart disease.
- **Find a family member or friend** who can come with you to the appointment, if possible. Someone who accompanies you can help remember what the doctor says.
- **Write down questions to ask** your doctor.

Questions to ask your doctor at your initial appointment include:

- What are the possible causes for my signs or symptoms?
- What tests do I need?
- Should I see a specialist?
- Should I follow any restrictions while I wait for my next appointment?



- What emergency signs and symptoms should prompt a call to 911?

Questions to ask if you are referred to a cardiologist include:

- What is my diagnosis?
- What is my risk of long-term complications from this condition?
- What treatment do you recommend?
- If you're recommending medications, what are the possible side effects?
- Am I a candidate for surgery? Why or why not?
- What diet and lifestyle changes should I make?
- What restrictions do I need to follow, if any?
- How frequently will you see me for follow-up visits?
- I have these other health problems. How can I best manage them together?

In addition to the questions that you've prepared to ask your doctor, don't hesitate to ask questions during your appointment.

What to expect from your doctor.

A doctor or cardiologist who sees you for heart-related signs and symptoms may ask:

- What are your symptoms?
- When did you first begin experiencing symptoms?
- Have your symptoms gotten worse over time?
- Do your symptoms include chest pain?
- Have you had any difficulty breathing?
- Does exercise or physical exertion make your symptoms worse?
- Are you aware of any history of heart problems in your family?
- Have you been diagnosed with any other health conditions?
- What medications are you currently taking?
- Have you ever been treated with radiation therapy?



- How much do you exercise in a typical week?
- What's your typical daily diet?
- Do you or did you smoke? How much?
- Do you drink alcohol? How much?

What you can do in the meantime.

It's never too early to make healthy lifestyle changes, such as quitting smoking, eating healthy foods and becoming more physically active. These are primary lines of defense against coronary artery disease and its complications, including heart attack and stroke.

Tests and diagnosis

The doctor will ask questions about your medical history do a physical exam and order routine blood tests. He or she may suggest one or more diagnostic tests as well, including:

- **Electrocardiogram (ECG).** An electrocardiogram records electrical signals as they travel through your heart. An ECG can often reveal evidence of a previous heart attack or one that's in progress. In other cases, Holter monitoring may be recommended. With this type of ECG, you wear a portable monitor for 24 hours as you go about your normal activities. Certain abnormalities may indicate inadequate blood flow to your heart.
- **Echocardiogram.** An echocardiogram uses sound waves to produce images of your heart. During an echocardiogram, your doctor can determine whether all parts of the heart wall are contributing normally to your heart's pumping activity. Parts that move weakly may have been damaged during a heart attack or be receiving too little oxygen. This may indicate coronary artery disease or various other conditions.
- **Stress test.** If your signs and symptoms occur most often during exercise, your doctor may ask you to walk on a treadmill or ride a stationary bike during an ECG. This is known as an exercise stress test. In some cases, medication to stimulate your heart may be used instead of exercise.

Some stress tests are done using an echocardiogram. For example, your doctor may do an ultrasound before and after you exercise on a treadmill or bike. Or your doctor may use medication to stimulate your heart during an echocardiogram.

Another stress test known as a nuclear stress test helps measure blood flow to your heart muscle at rest and during stress. It's similar to a routine exercise stress test but with images in addition to an ECG. Trace amounts of radioactive material — such as thallium or a compound known as sestamibi (Cardiolite) — are injected into your bloodstream. Special cameras can detect areas in your heart that receive less blood flow.



- **Coronary catheterization.** To view blood flow through your heart, your doctor may inject a special dye into your arteries (intravenously). This is known as an angiogram. The dye is injected into the arteries of the heart through a long, thin, flexible tube (catheter) that is threaded through an artery, usually in the leg, to the arteries in the heart. This procedure is called cardiac catheterization. The dye outlines narrow spots and blockages on the X-ray images. If you have a blockage that requires treatment, a balloon can be pushed through the catheter and inflated to improve the blood flow in your coronary arteries. A mesh tube (stent) may then be used to keep the dilated artery open.
- **CT scan.** Computerized tomography (CT) technologies, such as electron beam computerized tomography (EBCT) or a CT coronary angiogram, can help your doctor visualize your arteries. EBCT, also called an ultrafast CT scan, can detect calcium within fatty deposits that narrow coronary arteries. If a substantial amount of calcium is discovered, coronary artery disease may be likely. A CT coronary angiogram, in which you receive a contrast dye injected intravenously during a CT scan, also can generate images of your heart arteries.
- **Magnetic resonance angiogram (MRA).** This procedure uses MRI technology, often combined with an injected contrast dye, to check for areas of narrowing or blockages — although the details may not be as clear as those provided by coronary catheterization.



Treatments and drugs in CAD

Treatment for coronary artery disease usually involves lifestyle changes and, if necessary, drugs and certain medical procedures.

Lifestyle changes

Making a commitment to the following healthy lifestyle changes can go a long way toward promoting healthier arteries:

- Quit smoking.
- Eat healthy foods.
- Exercise regularly.
- Lose excess weight.
- Reduce stress.

Drugs

Various drugs can be used to treat coronary artery disease, including:

- **Cholesterol-modifying medications.** By decreasing the amount of cholesterol in the blood, especially low-density lipoprotein (LDL, or "bad") cholesterol, these drugs decrease the primary material that deposits on the coronary arteries. Boosting your high-density lipoprotein (HDL, or "good") cholesterol, may help, too. Your doctor can choose from a range of medications, including statins, niacin, fibrates and bile acid sequestrants.
- **Aspirin.** Your doctor may recommend taking a daily aspirin or other blood thinner. This can reduce the tendency of your blood to clot, which may help prevent obstruction of your coronary arteries. If you've had a heart attack, aspirin can help prevent future attacks. There are some cases where aspirin isn't appropriate, such as if you have a bleeding disorder or you're already taking another blood thinner, so ask your doctor before starting to take aspirin.
- **Beta blockers.** These drugs slow your heart rate and decrease your blood pressure, which decreases your heart's demand for oxygen. If you've had a heart attack, beta blockers reduce the risk of future attacks.
- **Nitroglycerin.** Nitroglycerin tablets, sprays and patches can control chest pain by opening up your coronary arteries and reducing your heart's demand for blood.
- **Angiotensin-converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARBs).** These similar drugs decrease blood pressure and may help prevent progression of coronary artery disease. If you've had a heart attack, ACE inhibitors reduce the risk of



future attacks.

- **Calcium channel blockers.** These medications relax the muscles that surround your coronary arteries and cause the vessels to open, increasing blood flow to your heart. They also control high blood pressure.

Procedures to restore and improve blood flow

Sometimes more aggressive treatment is needed. Here are a few options:

- **Angioplasty and stent placement (percutaneous coronary revascularization).** In this procedure, your doctor inserts a long, thin tube (catheter) into the narrowed part of your artery. A wire with a deflated balloon is passed through the catheter to the narrowed area. The balloon is then inflated, compressing the deposits against your artery walls. A stent is often left in the artery to help keep the artery open. Some stents slowly release medication to help keep the artery open.
- **Coronary artery bypass surgery.** A surgeon creates a graft to bypass blocked coronary arteries using a vessel from another part of your body. This allows blood to flow around the blocked or narrowed coronary artery. Because this requires open-heart surgery, it's most often reserved for cases of multiple narrowed coronary arteries.

Alternative medicine

Omega-3 fatty acids are a type of unsaturated fatty acid that's thought to reduce inflammation throughout the body. Omega-3 fatty acids can help lower your blood pressure and may reduce your risk of heart attack.

- **Fish and fish oil** are the most effective sources of omega-3 fatty acids. Fatty fish, such as salmon, herring and to a lesser extent tuna, contain the most omega-3 fatty acids and therefore the most benefit. Fish oil supplements may offer benefit, but the evidence is strongest for dietary sources.
- **Flax and flaxseed oil** also contain beneficial omega-3 fatty acids, though studies have not found these sources to be as effective as fish. The shell on raw flaxseeds also contains soluble fiber, which can help lower blood cholesterol.
- **Other dietary sources of omega-3 fatty acids** include walnuts, canola oil, soybeans and soybean oil. These foods contain smaller amounts of omega-3 fatty acids than do fish and fish oil, and evidence for their benefit to heart health isn't as strong.

Lifestyle and home remedies

Lifestyle changes can help you prevent or slow the progression of coronary artery disease.



- **Stop smoking.** Smoking is a major risk factor for coronary artery disease. Nicotine constricts blood vessels and forces your heart to work harder, and carbon monoxide reduces oxygen in your blood and damages the lining of your blood vessels. If you smoke, quitting is one of the best ways to reduce your risk of a heart attack.
- **Control your blood pressure.** Ask your doctor for a blood pressure measurement at least every two years. He or she may recommend more frequent measurements if your blood pressure is higher than normal or you have a history of heart disease. The ideal blood pressure is below 120 systolic and 80 diastolic, as measured in millimeters of mercury (mm Hg).
- **Check your cholesterol.** Ask your doctor for a baseline cholesterol test when you're in your 20s and then at least every five years. If your test results aren't within desirable ranges, your doctor may recommend more frequent measurements. Most people should aim for an LDL level below 130 milligrams per deciliter (mg/dL), or 3.4 millimoles per liter (mmol/L). If you have other risk factors for heart disease, your target LDL may be below 100 mg/dL (2.6 mmol/L).
- **Keep diabetes under control.** If you have diabetes, tight blood sugar control can help reduce the risk of heart disease.
- **Get moving.** Exercise helps you achieve and maintain a healthy weight and control diabetes, elevated cholesterol and high blood pressure — all risk factors for coronary artery disease. With your doctor's OK, aim for 30 to 60 minutes of physical activity most or all days of the week.
- **Eat healthy foods.** A heart-healthy diet based on fruits, vegetables and whole grains — and low in saturated fat, cholesterol and sodium — can help you control your weight, blood pressure and cholesterol. Eating one or two servings of fish a week also is beneficial.
- **Maintain a healthy weight.** Being overweight increases your risk of coronary artery disease. Weight loss is especially important for people who have large waist measurements — more than 40 inches (102 centimeters) for men and more than 35 inches (89 centimeters) for women — because people with this body shape are more likely to develop diabetes and heart disease.
- **Manage stress.** Reduce stress as much as possible. Practice healthy techniques for managing stress, such as muscle relaxation and deep breathing.

In addition to healthy lifestyle changes, remember the importance of regular medical checkups. Some of the main risk factors for coronary artery disease — high cholesterol, high blood pressure and diabetes — have no symptoms in the early stages. Early detection and treatment can set the stage for a lifetime of better heart health.

Also ask your doctor about a yearly flu vaccine. Coronary artery disease and other



cardiovascular disorders increase the risk of complications from the flu.

Prevention

The same lifestyle habits that can help treat coronary artery disease can also help prevent it from developing in the first place. Leading a healthy lifestyle can help keep your arteries strong, elastic and smooth, and allow for maximum blood flow. Heart-healthy habits include:

- Not smoking
- Controlling conditions such as high blood pressure, high cholesterol and diabetes
- Staying physically active
- Eating healthy foods
- Maintaining a healthy weight
- Reducing and managing stress

To widen narrowed coronary arteries, a balloon may be used to flatten fatty deposits and stretch the artery wall. A stent is often used to help keep the artery open.