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# Pulmonary embolism

## Introduction

Pulmonary embolism is a condition that occurs when an artery in your lung becomes blocked. In most cases, the blockage is caused by one or more blood clots that travel to your lungs from another part of your body.

Most clots originate in your legs, but they can also form in arm veins, the right side of your heart or even at the tip of a catheter placed in a vein. There are other rare causes of clots as well.

In most cases, a pulmonary embolism isn't fatal. Still, pulmonary embolism is a leading cause of hospital deaths and an increasing threat to passengers on long airplane flights. You can take measures to help prevent pulmonary embolism. And when pulmonary embolism does occur, treatment with anti-clotting medications can greatly reduce the risk of death.

## Signs and symptoms

Pulmonary embolism symptoms can vary greatly, depending on how much of your lung is involved, the size of the clot and your overall health — especially the presence or absence of underlying lung disease or heart disease.

Common signs and symptoms include:

- Sudden shortness of breath, either when you're active or at rest.
- Chest pain that often mimics a heart attack. The pain can occur anywhere in your chest and may radiate to your shoulder, arm, neck or jaw. It may be sharp and stabbing or aching and dull and may become worse when you breathe deeply (pleurisy), cough, eat, bend or stoop. The pain will get worse with exertion but won't go away when you rest.
- A cough that produces bloody or blood-streaked sputum.
- Rapid heartbeat (tachycardia).

Other signs and symptoms that can occur with pulmonary embolism include:

- Wheezing
- Leg swelling
- Clammy or bluish-colored skin
- Excessive sweating
- Anxiety
- Weak pulse
- Lightheadedness or fainting (syncope)
- Fever

## Causes

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You have two lungs, one on each side of your heart. Blood is constantly being pumped from the right side of your heart to the lungs and back to the left side of your heart. In your lungs, blood picks up oxygen and releases carbon dioxide, a waste product of metabolism. Blood vessels called arteries take the oxygen-rich blood to tissues throughout your body, and veins bring oxygen-poor blood back to the heart. Capillaries — the smallest blood vessels — connect the veins and arteries.

Clots that form in the veins throughout your body can dislodge, travel through the bloodstream to the right side of the heart, and then enter the pulmonary arteries, where they may cause a blockage. A blockage can occur in any small artery, but the lungs are especially vulnerable because all of the blood in the body passes through the lungs every time it circulates. Most often, a number of clots will shower your lungs during an episode of pulmonary embolism; it's unusual for just one clot to take place.

### Understanding blood clots

A blood clot is a plug of platelets — colorless blood cells that repair injured blood vessels — enmeshed in a network of red blood cells and fibrin, a type of protein. Clots normally develop to help stop bleeding after you've been cut or injured, but sometimes clots form for no apparent reason.

A blood clot that forms and remains in a vein is called a thrombus. A clot that travels to another part of your body is an embolus. Occasionally other substances, such as pieces of a tumor, globules of fat from fractured bones or air bubbles, may enter the bloodstream and become an embolus that blocks arteries.

Most clots that cause problems originate in a vein in your leg or pelvis. The affected vein may be near the surface of your skin (superficial thrombosis) or deep within a muscle (deep vein thrombosis, or DVT). Clots in superficial veins usually aren't serious and often clear on their own. But clots in the deep veins may detach and migrate through your bloodstream to your lungs.

The majority of clots in the legs begin in the veins below the knee, and it's uncommon for these clots to detach. But sometimes clots may extend up into the thigh, and that's when they tend to become dangerous. It's not known what causes clots to detach, and it's not possible to predict which clots will break off or when.

## Factors involved in clot formation

About half the people who develop abnormal blood clots have an inherited tendency to do so. Other factors that may cause unwanted clots to form include:

- **Surgery.** Operations are one of the leading causes of problem blood clots, especially operations to replace major joints, such as the hip and knee. Although people slated for high-risk operations are treated with anti-clotting drugs both before and after surgery, many still develop clots.
- **Long periods of inactivity.** Inactivity caused by prolonged bed rest or long plane or car trips decreases blood flow in your veins, making clots more likely. People who are immobilized after surgery, a heart attack or serious injuries are more apt to develop blood clots and pulmonary embolism than are people who are able to get up and walk around. In fact, the highest incidence of pulmonary embolism occurs among people in hospitals, where it's the third-leading cause of death.

In recent years, attention has also focused on the increasing incidence of deep vein thrombosis and pulmonary embolism among otherwise healthy travelers on long plane trips. Cramped seats with little legroom have contributed to the problem — so much so that deep vein thrombosis is sometimes referred to as "economy class syndrome." Not everyone who has DVT goes on to develop pulmonary embolism, however. For many people, the DVT causes few symptoms and is diagnosed long after the episode has passed.

- **Increased levels of clotting factors in the blood.** Some types of cancer, especially pancreatic, lung and ovarian cancers, cause increased blood levels of procoagulants — substances that contribute to blood clotting. The female hormone estrogen found in birth control pills and hormone therapy (HT) also increases the amount of clotting factors in the blood.
- **Certain medical conditions.** People who have cardiovascular disease associated with clot formation, such as heart attack (myocardial infarction) or stroke, are more likely to develop blood clots in their veins.
- **Injury to the veins.** This may occur during certain surgical procedures, especially hip surgery or knee replacement. It may also result from direct injuries to the legs or from leg or pelvic fractures.

## Risk factors

Although anyone can develop blood clots and subsequent pulmonary embolism — together known as venous thromboembolism (VTE) — the following factors increase your risk:

- **Inactivity.** You're not likely to develop a blood clot after an evening on the couch with a good book, but prolonged sitting in a cramped position during lengthy plane or car trips ups your risk. Inactivity slows the current of blood flow, which contributes to the formation of clots.

- **Prolonged bed rest.** Being confined to bed for an extended period after surgery, a heart attack, leg fracture or any serious illness makes you far more vulnerable to blood clots. Although pulmonary embolism is a leading cause of hospital deaths, it's also a serious problem for nursing home residents, who are likely to have a number of risk factors for DVT, as well as for people immobilized at home.
- **Certain surgical procedures.** Especially likely to cause blood clots are hip, pelvic and knee surgeries as well as some obstetric or gynecologic procedures.
- **Some medical conditions.** Certain cancers, especially pancreatic, ovarian and lung cancers can increase levels of substances that help blood clot, and chemotherapy further increases the risk. Women with a history of breast cancer who are taking tamoxifen or raloxifene also are at risk. High blood pressure and cardiovascular disease make clot formation more likely, as does having an inflammatory bowel disease such as ulcerative colitis or Crohn's disease.
- **Being overweight.** Researchers aren't certain why weighing more than normal increases the risk of blood clots, but one theory links the formation of clots to leptin, a hormone produced by fat cells in the body. People who are overweight have more leptin-producing cells than slender people do, and so may be more prone to develop clots. Another theory is that the fat in obese women contains estrogen, which contributes to clot formation.
- **Pacemakers or venous catheters.** Having a pacemaker or catheter — a soft, flexible tube — in a central vein makes the formation of clots more likely in that vein.
- **Pregnancy and childbirth.** Pulmonary embolism is the leading cause of death in pregnancy. Some women who have pregnancy-related venous thromboembolism also have an inherited clotting disorder.
- **Supplemental estrogen.** The estrogen in birth control and in hormone replacement therapy can increase clotting factors in your blood, especially if you smoke or are overweight.
- **Family history.** Having a personal or family history of venous thromboembolism increases the risk of blood clots.
- **Smoking.** For reasons that aren't well understood, tobacco use predisposes some people to blood clot formation, especially when combined with other risk factors.

## When to seek medical advice

Although it's possible to have deep vein thrombosis without any signs or symptoms, a clot often causes redness, swelling or tenderness over a vein in one of your legs. Because other conditions can cause similar problems, your doctor may order tests to confirm the diagnosis of a blood clot.

Once a clot has reached your lungs, the situation can be life-threatening, and you'll need to seek immediate medical care. About one in 10 people with pulmonary embolism dies within the first hour, so prompt treatment is crucial. Pulmonary embolism is seldom fatal when diagnosed and treated promptly.

Classic symptoms of pulmonary embolism include sudden shortness of breath, chest pain and a cough that produces blood-streaked sputum. However, symptoms can vary widely and often resemble those of other conditions.

## Screening and diagnosis

Pulmonary embolism can be difficult to diagnose, especially in people who have underlying heart or lung disease. For that reason, your doctor will perform one or more tests to help find the cause of your symptoms. These tests may include the following:

- **Chest X-ray.** This noninvasive test shows images of your heart and lungs on film. Although X-rays can't diagnose pulmonary embolism and may even appear normal when pulmonary embolism exists, they can rule out conditions that mimic the disease.
- **Lung scan.** This test, also called a ventilation-perfusion scan (V/Q scan), uses small amounts of radioactive tracers (radioisotopes) to study airflow (ventilation) and blood flow (perfusion) in your lungs. The radioisotopes are attached to substances known as radiopharmaceuticals.

In the first part of the test, you inhale a small amount of radiopharmaceutical while a camera that's able to detect radioactive substances takes pictures of the movement of air in your lungs. A small amount of a different radiopharmaceutical is then injected into a vein in your arm, and pictures are taken of blood flow in the blood vessels of your lungs. Comparing the results of the two studies helps provide a more accurate diagnosis of pulmonary embolism than does either study alone.

The entire procedure usually takes less than an hour. Although you're exposed to radioactive material, the amount of radioactivity is small. Still, the findings of many lung scans are indeterminate, requiring other tests to confirm a diagnosis of VTE. Furthermore, although a "normal" lung scan can rule out the possibility of pulmonary embolism, it doesn't rule out deep vein thrombosis (DVT) — the cause of pulmonary embolism. For these reasons, lung scans are being replaced by more sensitive and rapid tests, such as spiral computerized tomography (CT) scans.

- **Spiral (helical) computerized tomography (CT) scan.** A CT scan allows your doctor to see your organs in 2-dimensional "slices." Split-second computer processing creates these images as a series of very thin X-ray beams pass through your body. A dye (contrast medium) is commonly used to help visualize the area.

Another type of CT scan, called a spiral or helical CT, is fast becoming the first-line test for diagnosing suspected pulmonary embolism. A spiral CT differs from conventional computerized tomography in several ways: The scanner rotates continuously around your body, following a spiral path to create 3-dimensional images; it can detect abnormalities with a greater degree of accuracy, and it's faster, scanning your pulmonary arteries in less than 20 seconds as opposed to 20 minutes or more for a standard CT. Speed is important because it allows the dye to be "captured" while still in your arteries.

Spiral CT is nearly as sensitive in detecting most cases of pulmonary embolism as a pulmonary angiogram and much more sensitive than a lung scan. A spiral CT exposes you to more radiation than a standard X-ray does, as well as to the risk of an allergic reaction to the contrast medium.

- **Pulmonary angiogram.** This test provides a clear picture of the blood flow in the arteries of your lungs. It's the most accurate way to diagnose pulmonary embolism, but because it requires a high degree of skill to administer and carries potentially serious risks, it's usually performed when other tests fail to provide a definitive diagnosis.

In a pulmonary angiogram, a flexible tube (catheter) is inserted into a large vein — usually in your groin — and threaded through your heart into the pulmonary arteries. A special dye is then injected into the catheter, and X-rays are taken as the dye travels along the arteries in your lungs.

A risk of this procedure is a temporary change in your heart rhythm. In addition, the dye may cause kidney damage in people with decreased kidney function (renal insufficiency). Although the damage is usually temporary, it occasionally may become permanent. There is also the risk of developing a hematoma — a bruise that occurs when blood collects under the skin at the puncture site in your groin.

### Tests to detect blood clots

In addition to tests that check for pulmonary embolism, you may also have tests that help detect blood clots in your veins, such as:

- **D-dimer blood test.** Having high levels of the clot-dissolving substance D dimer in your blood may suggest an increased likelihood of blood clots, although D-dimer levels may be elevated by other factors, including recent surgery. Drawing the blood takes just a few minutes, and the risks — which include slight bleeding or a small accumulation of blood at the puncture site — are minor.

The results are available in less than an hour. Normal test results are actually much more meaningful than abnormal ones. That's because many conditions other than blood clots can cause elevated D-dimer levels, while a normal D dimer result essentially rules out the possibility of blood clots.

- **Ultrasound.** A noninvasive "sonar" test known as duplex venous ultrasonography (sometimes called duplex scan or compression ultrasonography) uses high-frequency sound waves to check for blood clots in your thigh veins. In this test, your doctor uses a wand-shaped device called a transducer to direct the sound waves to the veins being tested. These waves are then reflected back to the transducer and translated into a moving image by a computer.

The test is quick and painless, and very accurate for the diagnosis of blood clots behind your knee or in your thigh. However, ultrasound is not as accurate for detecting clots below the knee.

- **Venography.** A more complex and invasive procedure called venography can help reveal blockages caused by blood clots at any point in your arms or legs. During the test, a catheter is inserted into a vein in your foot or ankle. Because blood vessels aren't normally seen on X-rays, a contrast dye is injected into the vein to make it visible just before the X-rays are taken.

Although venography generally takes less than an hour, you'll need to keep your leg straight for six hours after the procedure. There are some risks, including an allergic reaction to the dye and a chance that the catheter may damage blood vessels or dislodge part of a clot. Although venography can accurately detect DVT, it's been replaced in large part by duplex ultrasonography.

- **Magnetic resonance imaging (MRI).** This test uses no X-rays. Instead, a computer creates tissue "slices" from data generated by a powerful magnetic field and radio waves. Because MRI is expensive, it's usually reserved for pregnant women and people whose kidneys may be harmed by dyes used in other tests.
- **Blood tests.** If you have a family history of blood clots, have had more than one episode of blood clots or have experienced clots for no known reason, your doctor may order a series of blood tests to look for inherited defects in your clotting system. If genetic abnormalities are found and you have a history of blood clots, your doctor may recommend lifelong therapy with anticoagulants to prevent future clotting problems. Also, if your genetic test results are abnormal, your doctor may recommend that other members of your family receive similar testing.

## Complications

Pulmonary embolism can be life-threatening. About one-third of people with undiagnosed and untreated pulmonary embolism don't survive. When the condition is diagnosed and treated promptly, however, that number drops dramatically. Once you've had one pulmonary embolism, you're at increased risk of more, and many of these recurrences can be fatal.

Pulmonary embolism can lead to several serious complications, including:

- **High blood pressure in your lungs (pulmonary hypertension).** A number of conditions can contribute to pulmonary hypertension. One occurs when a large number of clots obstruct blood flow in the blood vessels in your lungs for months or years, making the right side of your heart work especially hard against great resistance. This condition is reversible if the embolism is treated appropriately.

The most common symptoms of pulmonary hypertension are breathlessness (dyspnea) when you exert yourself and general fatigue. Fainting, dizziness, swollen legs or ankles, and pressure or pain in your chest also are common when pulmonary hypertension becomes severe.

- **Heart damage.** In a condition called cor pulmonale, the lower right pumping chamber of your heart (right ventricle) becomes enlarged and eventually fails as a result of problems in your lungs.

Blood flows from the right side of your heart into your lungs where it releases carbon dioxide and picks up oxygen. Normally, it doesn't take much pressure to push blood into your lungs, so the walls of the right ventricle aren't as strong as those on the left side of your heart, which pumps blood to the rest of your body. But when clots obstruct blood flow in your lungs, your heart has to pump harder.

Although your heart can compensate for a time, eventually the extra strain causes the muscle of the right ventricular wall to fail. This failure can occur within hours or even minutes if the blood clots are very large. It may occur over months or years if the obstruction is smaller and your condition goes undiagnosed.

## Treatment

Prompt treatment of venous thromboembolism — the term used to refer to both pulmonary embolism and deep vein thrombosis — is essential in order to prevent serious complications or death.

### A pair of anticoagulants

Initially you'll receive the fast-acting anticoagulant heparin, administered intravenously or under your skin (subcutaneously), which immediately helps prevent existing clots from enlarging and stops the formation of new ones. Your doctor is also likely to prescribe the anticoagulant warfarin, a pill that is given by mouth. Warfarin also helps stop clot formation, but because it works less quickly than heparin does, both drugs must be overlapped for at least five days, until the warfarin effect alone is enough to prevent clot formation.

After the original clot has dissolved, you'll likely continue to take an anticoagulant medication. How long depends on your particular case. If you have a chronic disorder that puts you at high risk of pulmonary embolism, you may need to stay on these drugs indefinitely. In general, though, you take them for at least three to six months.



### **Benefits, but risks as well**

As with all medications, the benefits of anticoagulants need to be weighed against the risks. Heparin and warfarin reduce your chance of developing blood clots, but because they may also prevent normal blood coagulation, they increase your risk of bleeding complications. Many of these complications are minor, such as bleeding from your gums, but some may be severe and life-threatening. If you're on warfarin, your doctor will ask you to have periodic blood tests to check how well the drug is working.

During anticoagulant therapy, avoid using aspirin unless you have heart disease and your doctor instructs you to continue taking a low dose. Also avoid other nonsteroidal anti-inflammatory drugs such as ibuprofen, which also affects your blood's ability to clot. Because more than 100 other drugs, including over-the-counter medications and some herbs, can interact with anticoagulants, be sure your doctor knows all the medications you're taking.

### **When pulmonary embolism is life-threatening**

If you experience a massive pulmonary embolism, if you have worsening cardiopulmonary disease, or if other treatments aren't effective, one of the following therapies may be an option:

- **Clot-dissolving (thrombolytic) therapy.** Rather than simply preventing clot formation, medications such as urokinase and the tissue plasminogen activator alteplase actually dissolve clots. They work by activating an enzyme that breaks down blood clots and are sometimes popularly referred to as "clotbusters."

You're not a candidate for these drugs if you are pregnant, have had a recent stroke, have severe high blood pressure or have undergone surgery within the past 10 days. Thrombolytic medications increase your risk of bleeding, especially from recent wounds, at needle puncture sites and in your digestive tract, but bleeding can occur anywhere, including your gums when you brush your teeth. Some bleeding may be fatal, especially if bleeding occurs in the brain.

- **Vein filter.** To attempt to block clots from being carried into the pulmonary artery, you may have a filter placed in the main vein (inferior vena cava) in your abdomen leading from your legs and pelvis to the right side of your heart. This is done by inserting the filter on the tip of a catheter through a vein in your groin or neck.

### **Prevention**

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[Support stockings](#)

Many cases of deep vein thrombosis and pulmonary embolism can be prevented with a few simple measures. Some of these measures are used in hospitals. Others are precautions you can take yourself.

### **Preventive steps in the hospital**

Because venous thromboembolism often gives few, if any warnings, doctors must take steps to help prevent blood clots in people recovering from a heart attack, stroke or surgery:

- **Heparin or warfarin therapy.** Anticoagulants such as heparin and warfarin are given to people at risk of clots both before and after an operation as well as to people admitted to the hospital with a heart attack, stroke or complications of cancer.
- **Graduated compression stockings.** Compression stockings steadily squeeze your legs, helping your veins and leg muscles move blood more efficiently. They offer a safe, simple and inexpensive way to keep blood from stagnating after general surgery. Compression stockings used in combination with heparin are much more effective than is heparin alone. Your doctor can help make sure your compression stockings have the right fit — they should be strong but not necessarily tight.
- **Use of pneumatic compression.** This treatment uses thigh-high or calf-high cuffs that automatically inflate every few minutes to massage and squeeze the veins in your legs. Pneumatic compression can dramatically reduce the risk of blood clots, especially in people who have had hip replacement surgery.
- **Physical activity.** Moving as soon as possible after surgery can help prevent pulmonary embolism and hasten recovery overall. This is one of the main reasons your nurse may push you to get up despite pain at the site of your surgical incision.

### **Preventive steps while traveling**

Sitting during a long flight or automobile ride increases your risk of developing blood clots in the veins of your legs. To help prevent a blood clot from forming:

- **Take a walk.** Move around the airplane cabin once an hour or so. If you're driving, stop every hour and walk around the car a couple of times or do a few deep knee bends.
- **Exercise while you sit.** Flex, extend and rotate your ankles or press your feet against the seat in front of you, or try rising up and down on your toes. And don't sit with your legs crossed for long periods of time.
- **Wear support stockings.** These help promote circulation and fluid movement. What's more, compression stockings no longer look like something your grandmother would wear — they're available in a range of stylish colors and textures.
- **Drink plenty of fluids before and during the trip.** Water is the best liquid for preventing dehydration, which can contribute to the development of blood clots. Avoid alcohol, which contributes to fluid loss.

- **Talk to your doctor.** If you're at high risk of blood clots and plan to fly six hours or more, your doctor may recommend taking low-molecular-weight heparin two to four hours before your departure.



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