

Stroke (brain attack)

Overview

Think of a stroke as a **"brain attack"** — it is an emergency! When symptoms appear, call 911 immediately; every minute counts. A stroke occurs when the brain is deprived of blood supply. Without oxygen, brain cells die. Depending on the area affected, a person may have problems speaking, walking, seeing, or thinking. A stroke may result in permanent brain damage or death. If the stroke is caused by a blood clot, a clot-busting drug or retrieval device may be used to restore blood flow.

Blood supply of the brain

To understand stroke, it is helpful to know how blood circulates to the brain (see Anatomy of the Brain). Blood is pumped from the heart and carried to the brain by two paired arteries, the internal carotid arteries and the vertebral arteries (Fig. 1). The internal carotid arteries supply the anterior (front) areas and the vertebral arteries supply the posterior (back) areas of the brain. After passing through the skull, the right and left vertebral arteries join together to form a single basilar artery. The basilar artery and the internal carotid arteries communicate with each other in a ring at the base of the brain called the Circle of Willis. The middle cerebral artery is the artery most often blocked during a stroke.

What is a stroke?

Stroke is a sudden interruption of the blood supply to the brain. Most strokes are caused by an abrupt blockage of an artery (ischemic stroke). Other strokes are caused by bleeding into brain tissue when a blood vessel bursts (hemorrhagic stroke). The effects of a stroke depend on the severity and which area of the brain is injured. Strokes may cause sudden weakness, loss of sensation, or difficulty with speaking, seeing, or walking. Since different parts of the brain control different areas and functions, it is usually the area immediately surrounding the stroke that is affected. Hemorrhagic strokes have a much higher death rate than ischemic strokes.

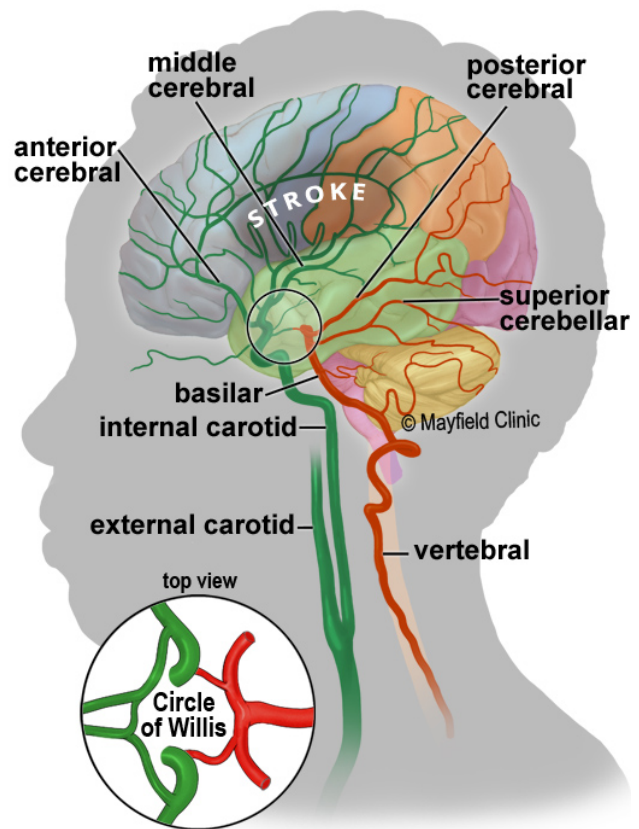


Figure 1. A stroke is a sudden interruption of the blood supply to the brain. The middle cerebral artery is most often blocked during a stroke. The internal carotid arteries form the anterior (green) circulation and the vertebral / basilar arteries supply the posterior (red) circulation of the brain. The two systems connect at the Circle of Willis (circle).

Frontal lobe (blue)

- Personality, behavior, emotions
- Judgment, planning, problem solving
- Speech: speaking and writing (Broca's area)
- Body movement (motor strip)
- Intelligence, concentration, self-awareness

Parietal lobe (orange)

- Interprets language, words
- Sense of touch, pain, temperature (sensory strip)
- Interprets vision, hearing, motor, sensory & memory
- Spatial and visual perception

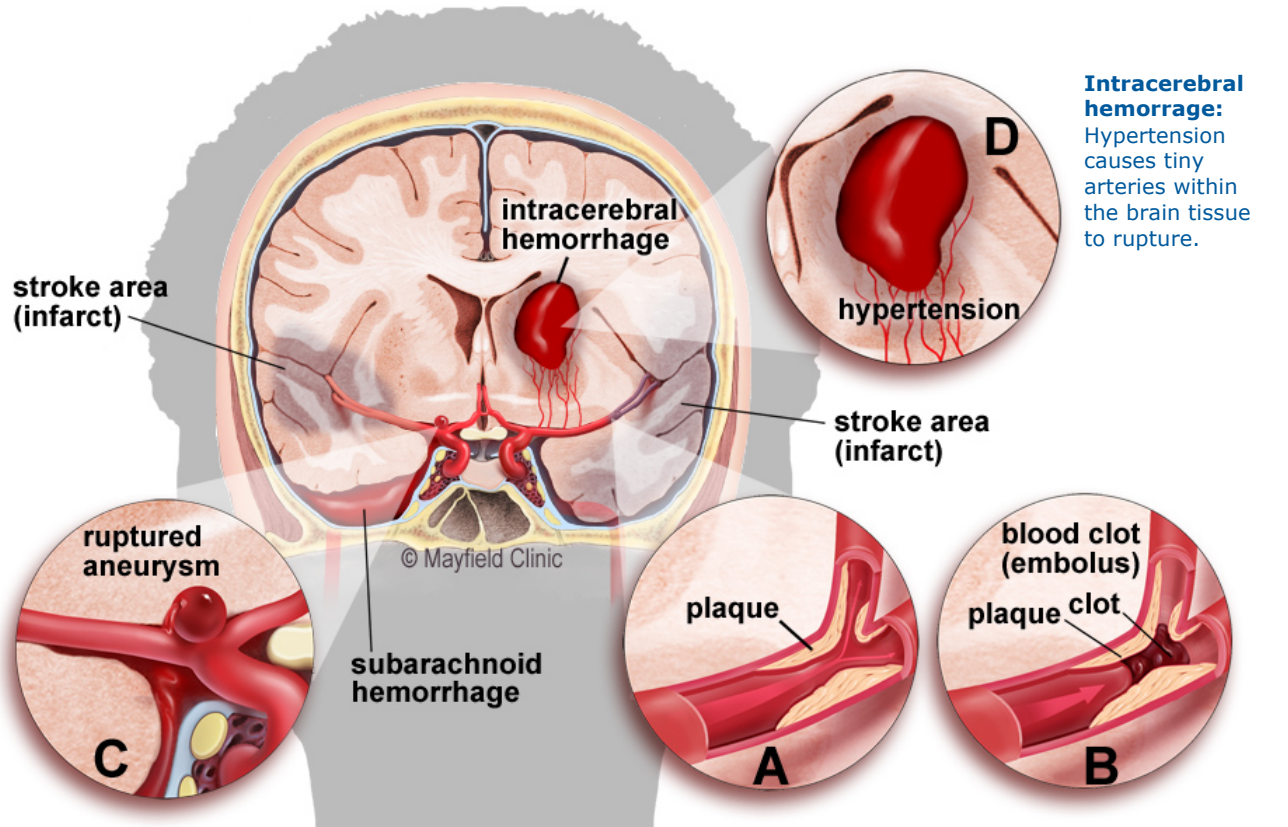
Occipital lobe (purple)

- Interprets vision (color, light, movement)

Temporal lobe (green)

- Understanding language (Wernicke's area)
- Memory
- Hearing
- Sequencing and organization

Figure 2. Types of stroke.



Subarachnoid hemorrhage:
A ruptured aneurysm releases blood into the spaces around the brain.

Ischemic stroke: A build-up of atherosclerotic plaques within an artery wall reduces blood flow to the brain.

Embolic stroke: Blood clots stick to plaques and break off, traveling downstream to block an artery.

Ischemic stroke: (most common - 87% of cases) is caused by a blockage of an artery from a blood clot (thrombus) or from clogged blood vessels due to atherosclerosis (hardening of the arteries). In atherosclerosis, cholesterol plaques are deposited within the walls of the arteries, narrowing the inside diameter of the artery (Fig. 2A). As the artery narrows, less blood is able to pass to the brain, and blood pressure increases to meet the demands of the body. The normally smooth inner wall of the artery is now roughed with plaque deposits, causing blood cells to build up and form clots (Fig. 2B). Clot build-up usually occurs in large blood vessels of the neck and base of the brain.

Embolic stroke: is caused when a clot breaks off from the artery wall and becomes an embolus, which can travel farther down the bloodstream to block a smaller artery. Emboli usually come from the heart, where different diseases cause clot formation.

Hemorrhagic stroke: (less common - 13% of cases) is caused by the rupture or leaking of an artery either within or around the brain. It can occur when a weakened blood vessel ruptures, releasing blood into the space surrounding the

brain. This is called a subarachnoid hemorrhage (SAH). It can be caused by a ruptured aneurysm (Fig. 2C), arteriovenous malformation (AVM), or head trauma. Bleeding within the brain tissue itself is called an intracerebral hemorrhage (ICH) and is primarily caused by hypertension (Fig. 2D). Hypertension is an elevation of blood pressure that may cause tiny arteries to burst inside the brain.

What are the symptoms?

Stroke symptoms may occur alone or in combination and may last a few minutes or several hours. If you or someone around you notices one or more of these warning signs, seek immediate medical attention. Poor public knowledge of stroke warning signs and risk factors limits effective stroke intervention and prevention. Even if stroke symptoms disappear, they are a clear warning that a larger stroke may follow.

- Sudden weakness or numbness of the face, arm or leg, usually on one side
- Difficulty speaking or understanding language
- Decreased or blurred vision in one or both eyes
- Sudden, severe headache
- Unexplained loss of balance or dizziness

If you notice signs of a stroke, think "FAST" and do the following:

- **Face.** Ask the person to smile. Does one side of the face droop?
- **Arms.** Ask the person to raise both arms. Does one arm drift downward? Or is one arm unable to raise up?
- **Speech.** Ask the person to repeat a simple phrase. Is his or her speech slurred or strange?
- **Time.** If you observe any of these signs, call 911 immediately. Note the time when symptoms first started.

Transient Ischemic Attacks (TIAs)

Sometimes strokes are preceded by mini-strokes, called transient ischemic attacks (TIAs), which last anywhere from a few minutes to several hours. TIAs occur when blood flow to the brain is temporarily interrupted and then restored. The symptoms resolve completely and the person returns to normal. TIAs are an important warning sign. It is possible to have several TIAs before a larger stroke occurs.

What are the causes?

Risk factors you **can't** modify

- Age - as a person ages, the chance of stroke increases.
- Gender - men are more likely than women to experience a stroke.
- Race - African Americans face twice the risk of stroke as Caucasians, while Hispanics are more likely to suffer a stroke at a younger age than non-Hispanic Caucasians.

Risk factors you **can** modify

- High blood pressure (hypertension) – this is the most dominant risk factor and the easiest to modify. Check your blood pressure regularly and keep it under control.
- Smoking – tobacco use doubles your stroke risk. If you smoke, stop.
- Weight - being overweight predisposes you to high cholesterol, high blood pressure, and diabetes, all of which increase stroke risk. If you are overweight, modify your diet and limit your intake of fatty foods.
- Diabetes - makes people susceptible to cardiovascular diseases, which can result in stroke. If you have diabetes, keep it well controlled.
- Prior stroke or TIA - increases your risk of having another stroke. Medications may decrease stroke risk if taken regularly.
- Heart disease - heart conditions, especially atrial fibrillation (an irregular heart beat), increase stroke risk. Certain medications may decrease the risk if taken regularly.

How is a diagnosis made?

When an individual is brought to the emergency room with an apparent stroke, the doctor will learn as much about the patient's symptoms, current and previous medical problems, current medications, and family history. The doctor also will perform a physical exam. If the patient can't communicate, a family member or friend will be asked to provide this information. Diagnostic tests are used to help doctors determine what is the cause and how to treat the stroke.

- **Lumbar puncture** is an invasive procedure in which a hollow needle is inserted into the subarachnoid space of the spinal canal to detect blood in the cerebrospinal fluid (CSF). If a hemorrhagic stroke is suspected, the doctor may perform a lumbar puncture.
- **Computed Tomography (CT)** is a scan performed for both ischemic and hemorrhagic strokes. CT is a safe, noninvasive X-ray that shows anatomical structures within the brain and whether there is any bleeding in or around the brain. CT angiography involves the injection of a contrast agent into the bloodstream, enabling doctors to view the arteries of the brain and find blockages.
- **Angiogram** is an invasive procedure in which a catheter is inserted into an artery and passed through the blood vessels to the brain. Once the catheter is in place, contrast dye is injected into the bloodstream and X-ray images are taken. This test is used to diagnose and determine the location of aneurysms and AVMs.
- **Magnetic resonance imaging (MRI)** is a scan and noninvasive test that uses a magnetic field and radiofrequency waves to give a detailed view of the soft tissues of the brain. An MRA (Magnetic Resonance Angiogram) is a similar test that allows doctors to not only view soft tissues but also to examine blood vessels in the brain.

What treatments are available?

Treatment for stroke depends on whether the patient is diagnosed with an ischemic or hemorrhagic stroke. In either case the person must get to a hospital immediately for the treatments to work.

Ischemic stroke treatments can be divided into emergency treatments to reverse a blockage and preventive treatments to prevent stroke.

Emergency procedures:

- Clot buster drugs (tPA)
- Clot retrieval devices

Preventive treatments:

- Blood thinners
- Angioplasty/stents
- Carotid endarterectomy

Hemorrhagic stroke treatment focuses on stopping the bleeding.

- see Subarachnoid hemorrhage (SAH)
- see Intracerebral hemorrhage (ICH)

Clot buster drugs

Thrombolytic "clot-buster" drugs help restore blood flow by dissolving the clot that is blocking the artery. The most common "clot-buster" is tissue plasminogen activator, or tPA for short. TPA is an enzyme found naturally in the body that dissolves clots. Doctors inject extra tPA into the bloodstream to speed up this process. To be effective, tPA (Activase) should be given as quickly as possible. Patients who received tPA within 3 to 4 hours of onset of stroke symptoms were at least 33% more likely to recover from their stroke with little or no disability after 3 months [1, 2].

TPA also can be delivered right at the clot site in a procedure called intra-arterial thrombolysis. In this method the tPA drug does not have to travel through the entire body before reaching the clot. A doctor called a neuro-interventionalist performs this procedure during an angiogram. A very small catheter is inserted into an artery in the groin and guided through the bloodstream up to the brain where the clot is located. The tPA drug is then released to dissolve the clot. The doctor also pushes the catheter back and forth through the clot to help break it up.

Clot retrieval devices

Large blood clots that block large arteries feeding the brain may not open fast enough with tPA. Stroke trials have shown that these larger blockages do not respond as often to this drug, even when it is given quickly. New devices, known as "thrombectomy devices," are designed to grab the clot that is blocking the artery and pull it out, leaving the artery open. A neuro-interventionalist, (also called a neuro-endovascular surgeon), performs the procedure during an angiogram. A catheter is inserted into an artery in the groin and then passed through the blood vessels to the blockage. Two different devices can be used to grab the clot and remove it (Fig. 5).

- A stent retriever (or "stentriever") is a wire mesh tube, like a stent, that is attached to a long wire. When the tube is opened in the blocked artery, the clot gets stuck in the mesh. The doctor then pulls out the mesh using the long wire, pulling out the clot with it.
- An aspiration catheter is like a vacuum cleaner that is attached to a special suction unit and used to suck out the clot.

Studies have shown that each of these devices is more likely to open a blocked artery than the clot buster drug alone and that patients with large-artery strokes are more likely to improve with this

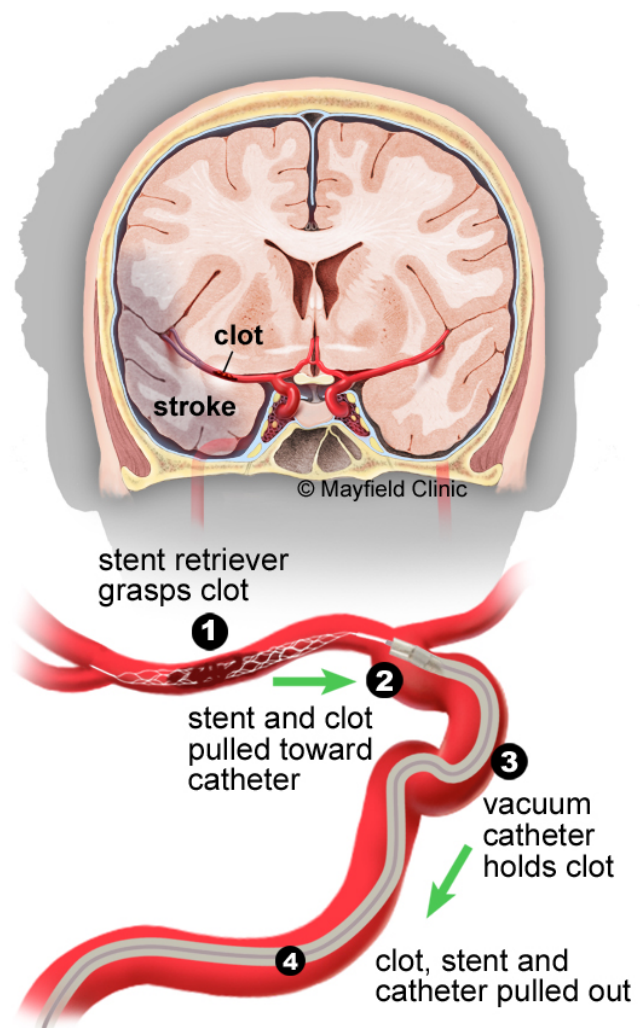


Figure 5. A stent retriever mesh is embedded in the clot and then used to pull the clot out of the artery and into the vacuum catheter.

treatment. Clot retrieval may be effective up to 6 hours after the onset of the stroke [3]. More recently, trials have shown that, for a small group of patients who wake up with stroke symptoms or are between 6 to 24 hours after onset, clot retrieval may still be effective. If specialized imaging shows that the territory of the stroke is small, removing the clot can prevent the stroke from getting larger and more severe [4]. Still, the earlier treatment begins the better.

Blood thinners

Anticoagulants ("blood thinners") such as warfarin, and antiplatelet agents such as aspirin, ticlopidine, dipyridamole, or clopidogrel interfere with the blood's ability to clot and can play an important role in preventing stroke.

Angioplasty

Angioplasty is used to open blood vessels narrowed or blocked by plaque build-up in atherosclerosis. A neuro-interventionalist performs it during an angiogram. A catheter is inserted into an artery in the groin and then passed through the blood vessels to the plaque build-up. The doctor guides the catheter through the bloodstream while watching a fluoroscopy (a type of X-ray) monitor. Once the catheter is positioned correctly, a balloon is inflated to flatten the plaques against the wall and open the artery to restore blood flow (Fig. 6).

Carotid endarterectomy

Sometimes plaque build-up is too great to treat with angioplasty, and the plaque must be surgically removed. A common area for build-up of plaques is at the common carotid arteries in the neck where the internal and external carotid arteries branch. If the carotid artery is more than 70% blocked, an endarterectomy surgery may reduce the risk of stroke by 65% [5]. Through an incision in the neck, the carotid artery is opened and the plaque removed to restore blood flow (Fig.7).

Recovery

Each person's mental and physical deficits are unique. Someone who has a small stroke may experience only minor deficits, such as weakness of an arm or leg, while someone who has a larger stroke may be left paralyzed on one side or lose his or her ability to speak. Some deficits may disappear over time with healing and therapy. The recovery process is long, and regaining function may take months or years. Rehabilitation professionals can help set up a treatment plan and help loved ones understand the patient's needs for assistance with daily living activities.

- **Aphasia**, caused by damage to the brain's language center, is a total or partial loss of the ability to understand or use words. Some people quickly and completely recover from aphasia after a stroke. Others may have permanent speech and language problems, which can range from trouble finding words to being unable to speak. Some people have problems understanding what others are saying or have trouble with reading, writing, or math. In other cases, someone may have trouble talking but can understand what others say.
- **Apraxia** is the inability to control muscles, making movements uncoordinated and jerky.
- **Dysarthria** is a loss of control over muscles in the face and mouth. A person's voice may sound slurred, muffled, or hoarse. The mouth may droop on one side of the face because of muscle weakness. Exercises can strengthen these muscles.
- **Dysphagia** is difficulty swallowing, making eating and drinking a challenge and choking a danger. Tongue and lip exercises can help individuals regain control.

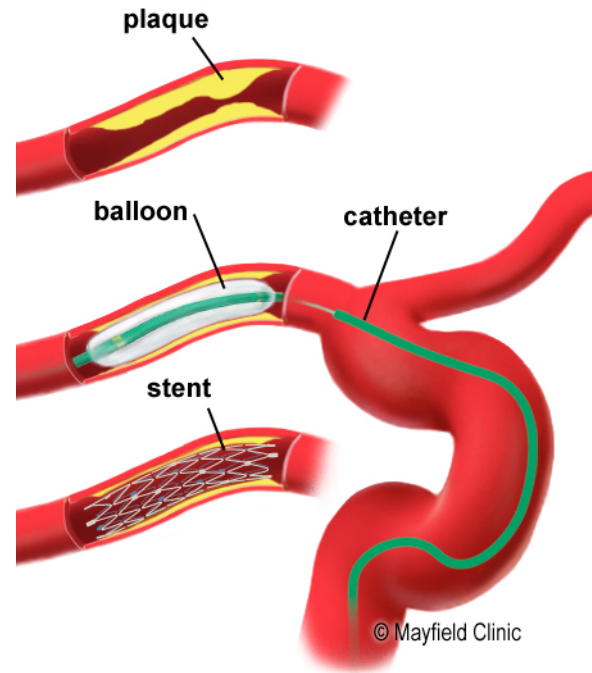


Figure 6. During angioplasty, a balloon-tipped catheter is placed within the narrowed vessel. The balloon is inflated compressing the plaque and opening the artery. The balloon is removed and a self-expanding mesh-like tube, called a stent, is placed over the plaque to hold open the artery. The stent remains in the artery permanently.

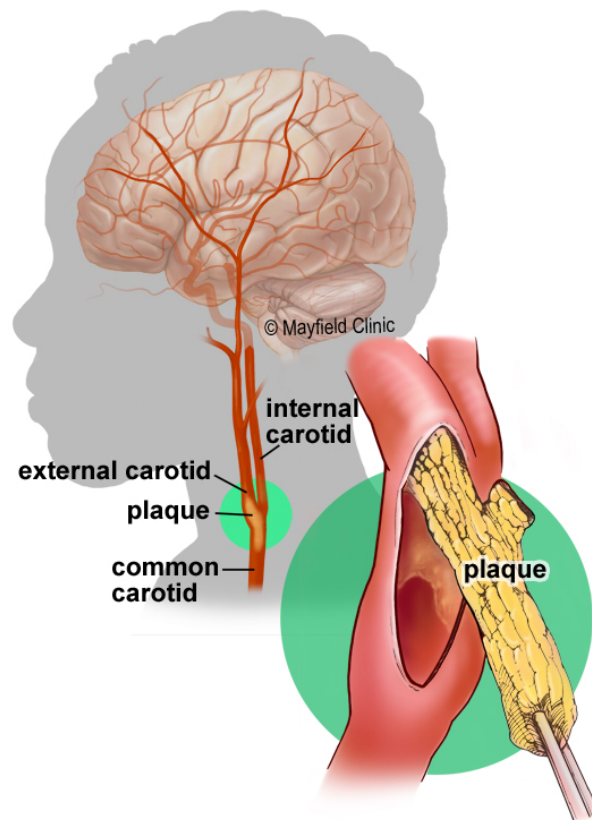


Figure 7. A carotid endarterectomy is a surgery to remove plaque from the area of the carotid artery where the internal and external carotid arteries branch.

- **Paralysis** is a loss of muscle function and sensation in an area of the body.
- **Hemiparesis** is a weakness of muscles on one side of the body. Improving posture, range of motion, and strength can help individuals regain control.
- **Hemianopia** is the loss of sight in half of the visual field.

Preventing another stroke

The link between cardiovascular health and stroke is inseparable. Of the 700,000 strokes suffered in the United States each year, about 200,000 are recurrent attacks. If you are at risk:

1. Take your medication every day as directed. Your medication helps to thin your blood and prevent clots.
2. Eat a healthy diet of foods low in fat, cholesterol, and salt.
3. Control your blood pressure.
4. Quit smoking.
5. Exercise regularly. You'll feel good about yourself, alleviate depression, control weight, and build muscle strength.
6. Get enough sleep and reduce stress.
7. Limit your use of alcohol. It can be risky to drink alcohol if you take certain medications. Talk to your doctor.
8. Talk about your feelings. Sudden mood swings and depression are common after a stroke and lessen with time. A support group or counselor can help you and your family.

Clinical trials

Clinical trials are research studies in which new treatments—drugs, diagnostics, procedures, and other therapies—are tested in people to see if they are safe and effective. Research is always being conducted to improve the standard of medical care. Information about current clinical trials, including eligibility, protocol, and locations, is found on the web. Studies can be sponsored by the National Institutes of Health (see www.clinicaltrials.gov) as well as private industry and pharmaceutical companies (see www.centerwatch.com).

Sources & links

If you have more questions, please contact Mayfield Brain & Spine at 800-325-7787 or 513-221-1100.

Sources

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3. A Randomized Trial of Intraarterial Treatment for Acute Ischemic Stroke, *N Engl J Med*, 372:11-20, 2015
4. Thrombectomy 6 to 24 Hours after Stroke with a Mismatch between Deficit and Infarct, *N Engl J Med*, 378:11-21, 2018
5. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med* 325:445-53, 1991.

Links

National Stroke Association, www.stroke.org
www.strokeassociation.org
www.strokecenter.org
 Brain Aneurysm Foundation, www.bafound.org

Glossary

aneurysm: a bulge or weakening of an arterial wall.

angioplasty: a procedure to insert an inflatable balloon to stretch open a blocked or narrowed artery; performed during an angiogram.

atherosclerosis: a degenerative disease of the arteries in which fatty plaques and scar tissue form on the inner walls and block the free flow of blood.

embolus: a blood clot or other substance such as air or fat, which is carried in the bloodstream from another site until it blocks a blood vessel.

embolization: inserting material or coil into an aneurysm so blood can no longer flow through it.

infarct: an area of dead tissue caused by a blockage of its blood supply.

intracerebral hemorrhage (ICH): bleeding directly into the brain tissue; may cause a updated stroke.

ischemia: a low oxygen state usually due to obstruction of the blood supply or inadequate blood flow leading to hypoxia in the tissue.

subarachnoid hemorrhage: bleeding in the space surrounding the brain; may cause a stroke.

tissue plasminogen activator (tPA): a thrombolytic "clot-buster" drug used to reduce the severity of ischemic stroke if given within three hours of stroke onset; can be given intravenously or by arterial catheter, but not by mouth.

thrombolysis: to break down or dissolve a clot.

thrombus: a blood clot.

transient ischemic attack (TIA): a "mini" stroke caused when blood flow to the brain is temporarily interrupted and then restored; causes no permanent brain damage.



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 reviewed by > Andy Ringer, MD, Mayfield Clinic, Cincinnati, Ohio

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