

## Stroke (brain attack)

### Overview

Think of a stroke as a **"brain attack"** - it is an emergency! Because a stroke can damage brain tissue, every minute counts. When symptoms appear call 911.

A stroke occurs when the brain is deprived of the oxygen it needs by an interruption of its blood supply. Without oxygen brain cells die. The oxygen-deprived area of brain tissue is called an **infarct**. Depending on what area of the brain has been affected, a stroke can cause problems with speech, behavior, thought patterns and memory, and may result in brain damage, disability or death.

### Blood supply of the brain

To understand stroke, it is helpful to understand the circulatory system of the brain (see Anatomy of the Brain). Blood is 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 occluded in 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.

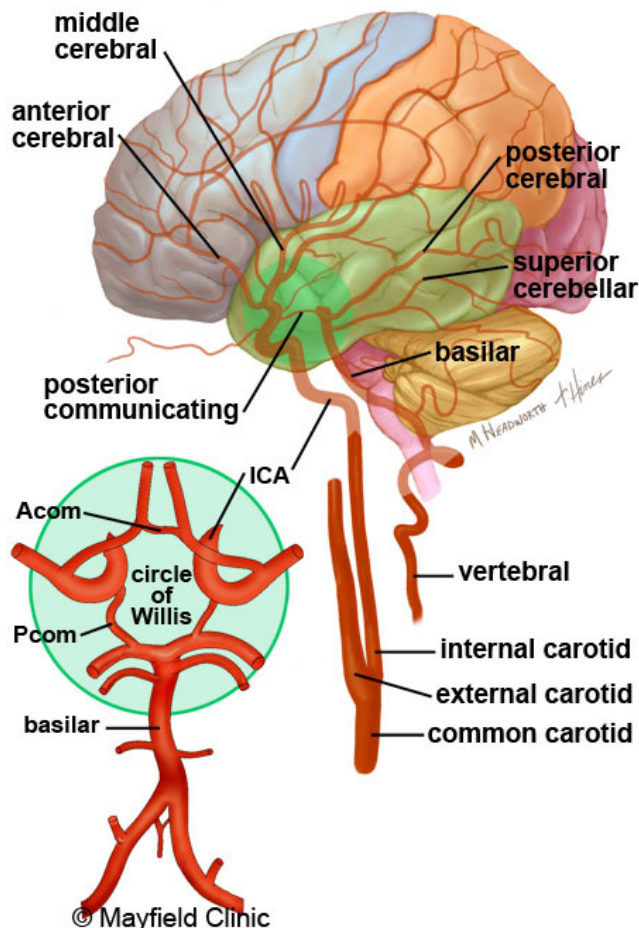


Figure 1. The front part of the brain is fed by the internal carotid arteries (ICA) and the back part of the brain is fed by the vertebral arteries (VA). The two systems connect at the Circle of Willis (green circle) by the anterior communicating (Acom) and posterior communicating (Pcom) arteries.

#### 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

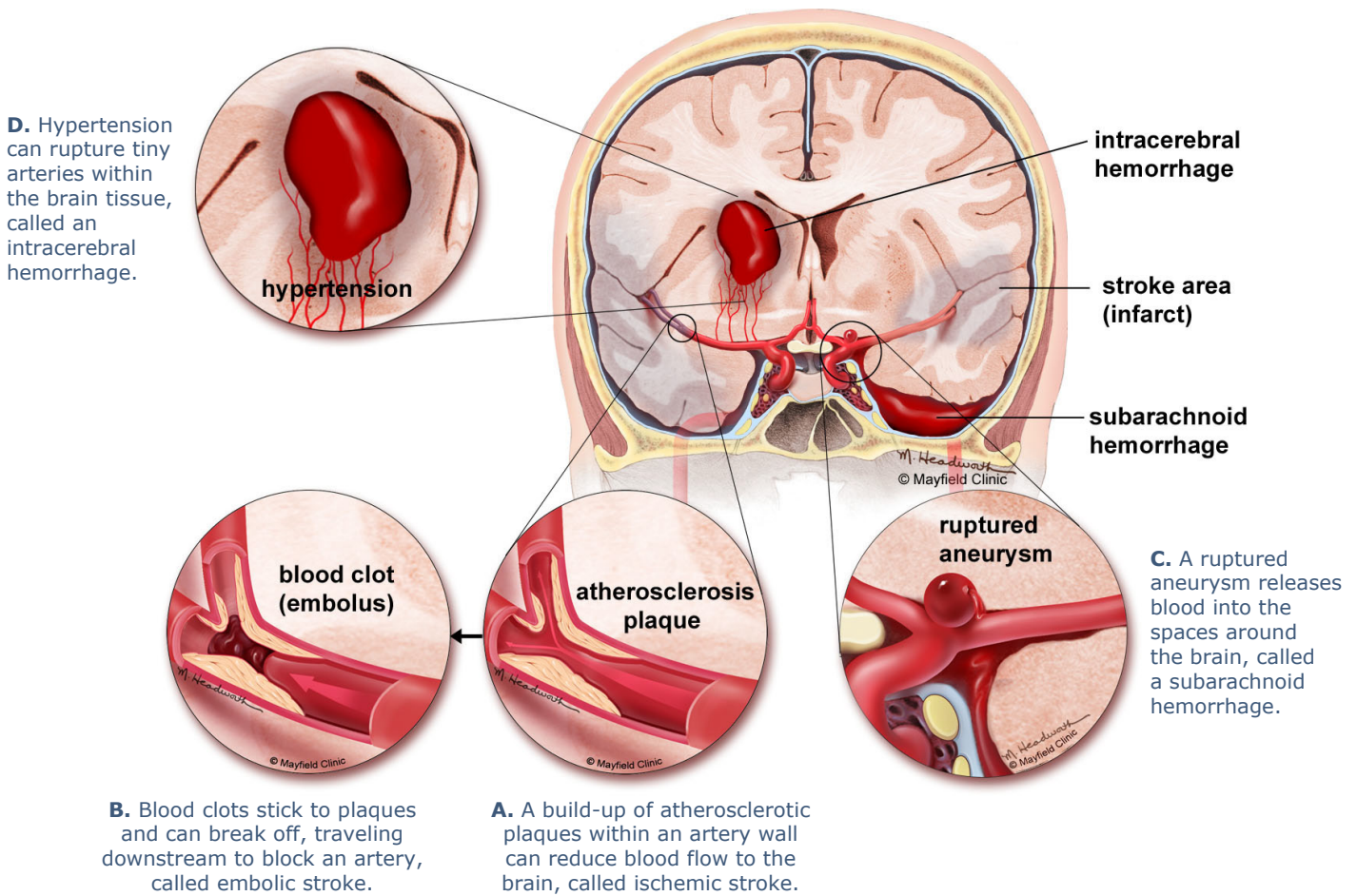
#### Occipital lobe (purple)

- Interprets vision (color, light, movement)

#### Temporal lobe (green)

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

**Figure 2. Types of stroke.**



**Ischemic stroke:** (most common - 83% 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 - called a thrombus (Fig. 2B). Thrombus build up usually occurs on 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 - 17% of cases) is caused by 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 notice 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 [1]. 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 headaches
- Unexplained loss of balance or dizziness

## Transient Ischemic Attacks (TIAs)

Sometimes strokes are preceded by mini-strokes, called transient ischemic attacks (TIAs), that last anywhere from a few minutes to several hours. TIAs result when blood flow to the brain is temporarily interrupted and then restored. The symptoms resolve completely and the person returns to normal. TIAs should not be ignored - they are an important warning sign. It is possible to have several TIAs before a larger stroke occurs.

## Who is affected?

Stroke is the third leading cause of death in the United States after diseases of the heart and all forms of cancer. About 600,000 Americans have strokes each year. Someone has a stroke every 53 seconds. Someone dies of a stroke every 3.3 minutes.

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.

Risk factors you **can** modify

- High blood pressure - the most dominant risk factor and the easiest to modify is hypertension. Check your blood pressure regularly and keep it under control.
- Smoking - doubles your stroke risk. If you smoke, stop.
- Weight - being over-weight predisposes you to high cholesterol, high blood pressure and diabetes, all of which increase stroke risk. If you are over weight, 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), have a greater stroke risk. Certain medications may decrease the risk if taken regularly.

## How is a diagnosis made?

When you or a loved one is brought to the emergency room with a stroke, the doctor will learn as much about your symptoms, current and previous medical problems, current medications, family history, and perform a physical exam. If you can't communicate, a family member or friend will be asked to provide this information. Diagnostic tests are used to help the doctors determine whether they need to unblock a clogged artery (in ischemic stroke) or stop the bleeding (in hemorrhagic 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)** scan is performed for both ischemic and hemorrhagic strokes. CT is a safe, noninvasive X-ray to review the anatomical structures within the brain to see if there is any bleeding in or around the brain. A newer technology called CT angiography involves the injection of contrast into the blood stream 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)** scan is a noninvasive test that uses a magnetic field and radiofrequency waves to give a detailed view of the soft tissues of your brain. An MRA (Magnetic Resonance Angiogram) is the same noninvasive study, except it is also an angiogram, which means it examines the blood vessels in addition to structures of the brain.

## What treatments are available?

For many years, there was little hope for those suffering an ischemic stroke. However, recent breakthroughs have led to new treatments that restore blood flow to the blood deprived (infarct) area. Thus, reducing secondary damage in the area surrounding the infarct, called the penumbra. In contrast, treatment for those suffering a hemorrhagic stroke focuses on stopping the bleeding. In either case the person must get to a hospital immediately for the treatments to work.

Ischemic stroke treatments

- Clot buster drugs (t-PA)
- Blood thinners (anticoagulants)
- Angioplasty/stents
- Carotid endarterectomy

## Clot buster drugs

Thrombolytic "clot-buster" drugs help restore blood flow by dissolving the clot blocking the artery. The most common "clot-buster" is tissue plasminogen activator, or t-PA for short. T-PA is an enzyme found naturally in the body that dissolves clots. Doctors inject extra t-PA into your blood stream to speed up this process. To be effective, t-PA (Activase) should be given as quickly as possible. Patients who received t-PA within 3 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 [2, 3].

T-PA can also be delivered right at the clot site in a procedure called intra-arterial thrombolysis. In this method the t-PA drug doesn't have to travel through your 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 your groin and guided through your bloodstream up to the brain where the clot is located. The t-PA 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. Typically this treatment option is only available at specialized stroke care centers.

### Blood thinners

Anticoagulants, or "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 positioned correctly, a balloon is inflated to flatten the plaques against the wall and open the artery to restore blood flow.

### Carotid endarterectomy

Sometimes plaque build-up is too great to treat with angioplasty and the plaque must be removed through surgery. 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, a surgical procedure called an endarterectomy may reduce your risk of stroke by 65% [4]. Through an incision in your neck the carotid artery is opened and the plaque removed to restore blood flow.

### Recovery

Each person's mental and physical deficits are unique. For example, someone who has a small stroke may experience only minor deficits such as weakness of an arm or leg. On the other hand, someone who has a larger stroke may be left paralyzed on one side or lose his/her ability to speak and process language. Some of these deficits may disappear over time with healing and therapy. The recovery process is long and may take weeks, months, or years to understand the level of deficits you incurred and regain function. Rehabilitation professionals can help set up a treatment plan and help others understand the stroke person's needs and help with daily living activities.

- **Aphasia** is a total or partial loss of the ability to understand or use words. Caused by damage to the brain's language center, some people quickly and completely recover from aphasia after a stroke. Others may have permanent speech and language problems. Speech problems 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 your muscles making movement uncoordinated and jerky.
- **Dysarthria** is a loss of control over muscles in the face and mouth. Their voice may sound slurred, muffled, or hoarse. The mouth may droop on one side of face due to 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 regain control.
- **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 regain control.
- **Hemianopia** is the loss of sight in half of visual field.

### Preventing another stroke

The link between cardiovascular health and stroke is inseparable. Of the 700,000 people who suffer a stroke each year, about 200,000 are recurrent attacks.

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, are found on the Web. Studies can be sponsored by the National Institutes of Health (see [www.clinicaltrials.gov](http://www.clinicaltrials.gov)) as well as private industry and pharmaceutical companies (see [www.centerwatch.com](http://www.centerwatch.com)).

## Sources & links

If you have more questions or would like to schedule an appointment with one of our neurosurgeons, please call (515) 241-5760. Our offices are located on the Iowa Methodist Campus.

### Sources

1. Schneider AT, Pancioli AM, Khoury JC, Rademacher E, Tuchfarber A, Miller R, Woo D, Kissela B, Broderick JP: Trends in community knowledge of the warning signs and risk factors for stroke. *JAMA* 289:343-6, 2003.
2. Tissue plasminogen activator for acute ischemic stroke. *N Engl J Med* 333:1581-7, 1995.
3. Marler JR, Tilley BC, Lu M, Brott TG, Lyden PC, Grotta JC, Broderick JP, Levine SR, Frankel MP, Horowitz SH, Haley EC Jr, Lewandowski CA, Kwiatkowski TP: Early stroke treatment associated with better outcome: the NINDS rt-PA stroke study. *Neurology* 55:1649-55, 2000
4. 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](http://www.stroke.org)

American Stroke Association  
[www.strokeassociation.org](http://www.strokeassociation.org)

[www.strokecenter.org](http://www.strokecenter.org)

[www.strokesupport.org](http://www.strokesupport.org)

[www.strokenetwork.org](http://www.strokenetwork.org)

Brain Aneurysm Foundation, [www.bafound.org](http://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.

**catheter:** a thin flexible tube made of rubber or plastic used to insert or remove fluids from the body.

**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, coil or glue, 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 arterial 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 (t-PA):** 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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