Stroke and the Family

A NEW GUIDE

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HARVARD UNIVERSITY PRESS
Cambridge, Massachusetts
London, England
2004

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Finding the Cause of a Stroke

Nicholas is a sixty-five-year-old recently retired accountant on a vacation cruise with his wife when he wakes up one morning with mild left-sided weakness. He is brought by helicopter to a hospital, where he is diagnosed with a cerebral infarction—a stroke. Within the first forty-eight hours he undergoes a CT scan, an MRI, an echocardiogram, and carotid ultrasound tests. While in the hospital he quickly regains most of his strength on the left side, but he wants to understand why all these tests were performed and what they show. What caused his stroke? Is he likely to have another one? What can he do to prevent future strokes?

Cerebral infarcts all result from interruption of blood flow to a portion of the brain, but they have a variety of specific causes. Determining the cause is particularly important when selecting treatment(s) to prevent another stroke. A number of tests are useful in determining the cause, though the actual selection of these tests will vary depending on the circumstances and availability. These tests include:

Computerized tomography (CT or CAT scan) of the brain. CT is a special computerized x-ray of the brain. CT scans can show the location and size of a stroke (see Figure 2.1). They can be performed quickly and are very good at finding any bleeding in the brain (see Figure 2.2). Damage from an infarct is not always visible when the scan is done soon after symptoms of a cerebral infarct develop, however.

Magnetic resonance imaging (MRI scan) of the brain. MRI provides very detailed pictures of the brain and does not involve any radiation. MRI scans typically take longer to perform than CT scans, but they may be better

FIGURE 2.1 *Cerebral infarction.*
This CT of the brain shows a large infarct in the patient's left frontal and parietal lobes. The stroke appears darker than the surrounding brain. There is a small amount of bleeding within the stroke, visible as small areas that are lighter than the surrounding stroke.

FIGURE 2.2 *Cerebral hemorrhage.*
This CT of the brain shows a large hemorrhage in the patient's right basal ganglia. The blood appears brighter than the surrounding brain tissue. A rim of edema (swelling) is seen around the blood and is darker than both the blood and the surrounding brain.

able to detect a stroke (especially an infarct) very early after symptoms develop. Certain people cannot undergo MRI, including those with pacemakers or other metallic objects in their body.

Magnetic resonance and computerized tomographic angiography. These techniques are used to provide pictures of the blood vessels supplying the brain. They are noninvasive and safe, and frequently provide sufficient information to direct treatment. In some circumstances conventional angiography is needed to provide even more detailed images.

Conventional angiography. In this procedure, detailed pictures of the blood vessels to the brain are taken by injecting a dye into the blood vessels via a special catheter (long, flexible tube). This is a more invasive procedure than MR or CT angiography and may carry some risk of adverse side effects, including stroke in rare cases.

Echocardiogram. In an echocardiogram, an ultrasound machine takes pictures of the heart using sound waves. These sound waves are at a high frequency and are beyond the range of human hearing. The sound waves bounce off the internal organs and are used to create a picture of the heart. There are two types of echocardiogram—a conventional or "transthoracic" echocardiogram, in which the recording head of the ultrasound machine is placed on the outside of the chest wall, and a "transesophageal" echocardiogram, in which the recording head of the ultrasound is swallowed and pictures are obtained from within the esophagus (the tube connecting the mouth with the stomach). Transesophageal echocardiograms provide more detailed pictures, and may be needed in certain circumstances to determine the cause of a stroke.

Electrocardiogram (ECG). Electrocardiogram, or ECG, is a routine recording of the heart's electrical activity. This is a simple and useful test for identifying damage to the heart, or an abnormal heart rhythm that may be responsible for a stroke.

Carotid ultrasound/transcranial doppler. This is another form of ultrasound that provides pictures and other information about the structure and functioning of the major blood vessels in the head and neck.

Holter monitor. Similar to an electrocardiogram, but obtained over a longer period of time (usually twenty-four hours), this test involves a special tape recorder that is carried by the patient. It can be useful in detecting abnormal heart rhythms that are intermittent and can cause stroke.

Blood tests for blood clotting. These tests check for abnormalities of blood clotting that can lead to stroke.

Lipid profile. This blood test, generally obtained after the patient has been fasting, provides information about fatty components of the blood, such as cholesterol and triglycerides, which can contribute to the risk of stroke. This test determines levels of high-density lipoprotein (HDL), the "good cholesterol" associated with a reduced risk of stroke, and low-density lipoprotein (LDL), the "bad cholesterol" that increases the risk of stroke and heart disease.

Types of Stroke

On the basis of the information obtained from these tests, physicians can usually identify the type and cause of the stroke. Ischemic strokes are often divided into several categories, depending on how the stroke occurs. Certain medical conditions may predispose individuals to particular types of stroke.

Embolic Stroke

Embolic stroke is caused by a clump of material traveling through the bloodstream and blocking a blood vessel in the brain. The substance causing an embolic stroke is most commonly a blood clot, though there are other substances that can "embolize" and cause stroke in rare cases, including pieces of cholesterol, fat from the middle of bones after a severe fracture, and even air. Blood clots can originate in a number of areas, as described below.

ATRIAL FIBRILLATION

A particularly common cause of blood clots forming in the heart is a condition known as "atrial fibrillation." In atrial fibrillation, the two smaller

chambers of the heart, known as the atria, do not beat regularly and so cannot empty out all the blood they contain. Instead, the individual heart cells contract in an uncoordinated fashion, leading to inefficient pumping of the blood. This causes the blood to stagnate in the heart, allowing the formation of blood clots within the left atrium. These clots can break off and travel to the brain, causing a stroke. Warfarin (best known by its brand name, Coumadin) is the usual treatment for this condition, though aspirin is often used for individuals at low risk for stroke, and is a useful alternative for those unable to take Coumadin for medical reasons.

CARDIOEMBOLIC STROKE

Blood clots can originate in other parts of the heart, including the left ventricle, the main pumping chamber of the heart. This usually occurs when there is substantial heart disease and the heart is not pumping normally. In this case blood may have a chance to form a clot within the heart, resulting in a stroke if a piece of the clot breaks off and ends up in a blood vessel supplying the brain. The standard treatment is anticoagulation with Coumadin (warfarin) to prevent further clot development.

AORTIC ARCH EMBOLI

In recent years a relationship has been demonstrated between atherosclerosis (fatty deposits in the blood vessel wall) of a portion of the aorta, the main blood vessel carrying blood from the heart, and stroke. It is suspected that atherosclerosis in this area leads to an irregular surface inside the aorta, which allows clots to form and subsequently break off. These clots can then block a blood vessel in the brain and cause a stroke. Treatment typically involves Coumadin (warfarin) or aspirin to prevent another stroke.

PARADOXICAL EMBOLI

Before birth, there is normally an opening between the two smaller chambers of the heart (known as the atria). In most individuals this opening closes at birth, but it may remain open in some people throughout adulthood. This condition is usually asymptomatic. The opening is known as the "foramen ovale," and when it remains open after infancy, it

is known as a "patent foramen ovale," sometimes abbreviated as PFO. In individuals with normal heart anatomy, the blood coming back from the body travels through the lungs before being pumped back to the head and body. The small blood vessels in the lungs function as a sort of filter, "catching" any blood clots that may be present. This filtering function prevents any of these clots from traveling to the brain and causing a stroke. In individuals with a PFO, however, some of the blood returning from the body bypasses the lungs and is pumped directly back to the brain and body. If there is a blood clot contained in this blood, it may be carried to the brain and cause a stroke. Fortunately, blood clots traveling in the blood are a relatively uncommon event, so individuals with a PFO may never have any symptoms. Nonetheless, PFO is increasingly recognized as a cause of stroke, particularly in young people without other known causes for stroke. Treatment for a PFO may include anticoagulation (Coumadin) or closure of the opening. This closure can now be performed in some centers via a catheter, thus preventing open-heart surgery.

Atherothrombotic Stroke

Atherothrombotic strokes are those that occur as a result of a blockage of the blood vessels supplying blood to the brain. These are often divided into two distinct subgroups: blockages of the small blood vessels within the brain ("lacunar strokes") and blockages of the large vessels supplying the brain.

LACUNAR INFARCTS

Blockages of the small blood vessels within the brain can cause small strokes known as lacunar infarcts. Because of their small size, the effects of these strokes vary widely. Some lacunar strokes do not cause any symptoms and are only detected incidentally on a CT or MRI of the brain. Others occur in critically important areas of the brain and can lead to severe weakness of an entire side of the body. This type of stroke is strongly associated with hypertension. Blood pressure control and antiplatelet medications (such as aspirin) are the main preventative measures.

CAROTID ARTERY NARROWING AND BLOCKAGE

Blockage ("stenosis") of the large blood vessels in the neck, the carotid arteries, can cause stroke (see Figure 2.3). These blockages often develop gradually over a long period of time and can be detected through ultrasound testing. Surgical treatment for these blockages is known as an "endarterectomy" and consists of removal of the inner layers of the blood vessel creating the blockage. This surgery is effective in preventing future strokes but does carry some risk of stroke at the time of surgery. Having the surgery performed by an experienced surgeon at a center that does a large number of these procedures appears to be the best approach for minimizing this risk. Complete blockage of one of these blood vessels (known as a carotid "occlusion") is generally not amenable to surgery, and in such cases medications are used to reduce the risk of future stroke.

Recently, experimental devices have been developed to keep these arteries open without surgery. These devices, known as "stents," are placed inside the blood vessel through a nonsurgical procedure in which a long, thin, flexible tube (catheter) is threaded through the blood vessels starting in the arm or groin area. The stent, a tubular, expandable wire mesh device, is then placed in the area of blockage using the catheter, and expanded to hold the blood vessel open. This treatment remains experimental and is being studied at a number of centers. It is not suitable for all blockages, depending on the specific anatomical issues in each case. Medical treatment with Coumadin (warfarin) or antiplatelet medications such as aspirin or clopidogrel (Plavix) is sometimes used for lesser degrees of blockage, while the patient awaits surgery, or in individuals who are unable to undergo surgery. Surgery remains the most common treatment at present for moderate to severe blockages.

VERTEBROBASILAR STENOSIS

In addition to the two large carotid arteries on each side of the neck, there is a third major artery supplying blood to the brain—the basilar artery. The basilar artery receives its blood from two arteries in the neck known as the vertebral arteries. Like the carotid arteries, any or all of these arteries may become blocked over time. Unfortunately, because of their location, these arteries are not presently amenable to surgical treat-

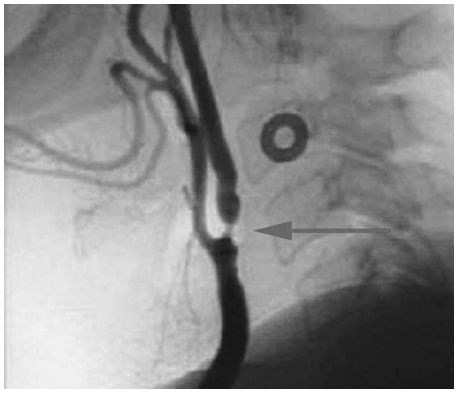

FIGURE 2.3 *Carotid stenosis.*
The carotid arteries are shown in black in this angiogram. The narrowing (stenosis) of the internal carotid artery is visible at the arrow.

ment. Medical treatment (with aspirin, for example) is the usual approach. As with carotid artery blockages, research on the use of stents to hold the artery open is ongoing.

INTRACRANIAL STENOSIS

Blood vessels within the head can become progressively narrowed and blocked, leading to the development of a stroke. Because of the location of these blood vessels within the skull, they cannot be corrected by surgery. The usual treatment in this situation is an anticoagulant, such as Coumadin (warfarin), or an antiplatelet medication, such as aspirin or Plavix (clopidogrel).

CRYPTOGENIC STROKE

"Cryptogenic" is an elegant way of saying "unknown cause," and cryptogenic strokes are those for which no cause can be determined. Despite the extensive diagnostic tests undertaken, a cause remains unidentified for a significant number of strokes. Treatment of these strokes generally involves antiplatelet medications, such as aspirin or Plavix (clopidogrel), or Coumadin (warfarin).

Other Types of Stroke

WATERSHED INFARCTS AND ANOXIC ENCEPHALOPATHY

Any condition that leads to severely reduced blood pressure and blood flow can result in a stroke or brain damage. Examples of this include a fall in blood pressure that occurs during surgery, or temporary loss of blood flow during a cardiac arrest. When blood flow is substantially reduced, the strokes that result commonly occur in the boundaries between areas of the brain supplied by different arteries, rather than being centered in the area supplied by a specific artery. These strokes are often referred to as "watershed" infarcts, because they occur at the boundary between two areas of blood circulation, or "watersheds." In some cases, such as cardiac arrest, blood flow to the entire brain is compromised simultaneously. In these cases, damage is more diffuse throughout the brain, with some areas more sensitive to the injury than others. Failure of blood or oxygen flow to the entire brain is known as an "anoxic" injury (meaning lack of oxygen). Memory problems are often very prominent in these type of injuries and may be the major long-term effect.

ARTERIAL DISSECTION

Blockage of a blood vessel leading to a stroke can be caused by a separation that forms between the inner layer of a blood vessel and the outer layers, resulting in a blockage in the artery. This is known as an arterial dissection. This is a cause of stroke in otherwise young, healthy individuals who do not have the usual risk factors for stroke. Arterial dissection often occurs after a minor injury, often one involving twisting or bending of the neck, though sometimes no injury can be identified. Chiropractic manipulation of the neck has been found to result in arterial dissection in a small number of people. Some individuals appear to have a genetic predisposition to this type of stroke, but the exact reason a dissection occurs often remains unknown. Treatment involves anticoagulation with heparin and then Coumadin (warfarin) for a period of time.

HYPERCOAGULABLE STATES

Several abnormalities of blood clotting cause the blood to clot (coagulate) more easily and quickly than normal. These disorders are known as "hypercoagulable" conditions. Most are genetic and are frequently

asymptomatic. In a minority of individuals, however, this increased tendency to form clots can lead to a stroke. Some hypercoagulable states develop as the result of an acquired condition rather than a genetic one. These include antiphospholipid antibody syndrome, in which the body forms antibodies against itself, and the hypercoagulable state frequently present in people with cancer. Treatment for hypercoagulable conditions varies according to the severity and type of disorder and often involves anticoagulants such as Coumadin (warfarin).

The use of oral contraceptives can increase the risk of clotting somewhat and is implicated as a cause of stroke in some young women. For this reason, the use of oral contraceptives may be inadvisable in young women who have suffered a stroke, even if they were not using these medications at the time of their stroke. The combination of smoking and older age (for example, being in your forties versus your twenties) appears to increase the risk of stroke associated with oral contraceptives.

MIGRAINOUS STROKES

Migraine headaches are very common, affecting millions of Americans. In a very small number of cases, migraine headaches can be associated with stroke in a young adult. This is believed to be caused by severe spasm of the blood vessels, leading to a blockage of blood supply to a portion of the brain. The use of oral contraceptives in young women with migraine headaches seems to increase the risk of this type of stroke.

STROKES CAUSED BY ILLICIT DRUG USE

Certain illicit drugs, most notably cocaine and amphetamines, are known to cause ischemic strokes or hemorrhagic strokes in a small number of people.

CEREBRAL VENOUS THROMBOSIS

This relatively rare type of stroke involves not the blood vessels bringing the blood to the brain (arteries) but rather the blood vessels that drain the "used" blood away from the brain (veins). In cerebral venous thrombosis, a clot develops within these veins, causing the blood to "back up" within the brain. This results in a stroke, which can develop superimposed bleeding in some cases (see "Hemorrhagic Conversion"). The treatment for this type of stroke is anticoagulants such as heparin and Coumadin.

Cerebral Hemorrhage

Cerebral hemorrhage, or bleeding in the brain, has several causes. Although the effects of cerebral hemorrhage resemble ischemic stroke in many ways, their causes are quite distinct.

HYPERTENSIVE HEMORRHAGE

Elevated blood pressure can cause rupture of a blood vessel within the brain, known as a hypertensive hemorrhage. The worse the hypertension, the higher the likelihood of such a hemorrhage occurring. In a famous example, Franklin D. Roosevelt died in office of a cerebral hemorrhage caused by uncontrolled hypertension. Fortunately, many medications to control high blood pressure are now available, allowing effective blood pressure control in the vast majority of individuals with hypertension.

CEREBRAL AMYLOID ANGIOPATHY

In some older individuals, an abnormal protein is deposited in the walls of the blood vessels in the brain, causing the blood vessels to become fragile. This can result in rupture of the blood vessels and cerebral hemorrhage. This condition, known as cerebral amyloid angiopathy (CAA), can be difficult to diagnose with certainty in some cases. Unfortunately, there is no effective treatment for this disorder at the present time, and recurrent hemorrhages are possible. Avoiding medications known to increase the risk of bleeding, such as aspirin or Coumadin (warfarin), as well as alcohol is advised. Good control of hypertension, if present, is also advisable, since elevated blood pressure may increase the risk of a hemorrhage due to cerebral amyloid angiopathy. Research on possible treatments for this condition is ongoing (see Appendix).

ANEURYSMS

There are several types of malformations of the blood vessels that can cause a hemorrhagic stroke. One of the more common types is an aneurysm, which is an out-pouching of one of the larger arteries in the brain (see Figure 2.4). Aneurysms tend to run in families and can be asymptomatic for many years. Larger aneurysms have a greater risk of bursting and typically cause bleeding around the brain rather than inside it. This