Cerebral Artery Bypass Surgery

Overview
Cerebral bypass surgery is performed to restore, or "revascularize," blood flow to the brain. A cerebral bypass is the brain’s equivalent of a coronary bypass in the heart. The surgery connects a blood vessel from outside the brain to a vessel inside the brain to reroute blood flow around a damaged or blocked artery. The goal of bypass surgery is to restore blood supply to the brain and prevent strokes.

What is cerebral artery bypass?
Blood carries nutrients and oxygen to the brain through four main arteries: the right and left carotid arteries and the right and left vertebral arteries. Poor delivery of blood flow reduces the brain’s ability to function. Called cerebrovascular insufficiency, a lack of blood supply leads to transient ischemic attacks (TIA), stroke, and ultimately brain cell death. In a cerebral artery bypass, the surgeon reroutes blood flow around a blocked or damaged artery to improve or restore blood flow to an oxygen-deprived (ischemic) area of the brain. A cerebral bypass can be performed in a variety of ways depending on where the blockage has occurred, the underlying condition being treated, and the size of the brain area to be revascularized. There are two types of bypasses:

The first type uses a vessel graft – a length of artery or vein harvested from somewhere else in the body. The graft is connected above and below the blocked artery so that blood flow is rerouted (bypassed) through the graft. Common vessels used as a graft are the saphenous vein in the leg or the radial or ulnar arteries in the arm. A separate incision is required to harvest the graft. Next, one end of the graft is connected to the external carotid artery (ECA) in the neck and then tunneled under the skin in front of the ear to the scalp. A hole is cut in the skull through which the graft is passed and connected to an artery on the surface of the brain. This method is typically used when a large (high-flow) artery is affected or needs to be sacrificed to treat a tumor or aneurysm.

The other type does not use a vessel graft but a healthy donor artery that flows in the scalp or face. The donor artery is detached from its normal position on one end, redirected to the inside of the skull, and connected to an artery on the surface of the brain (Fig. 1). The scalp artery now supplies
blood to the brain and bypasses the blocked or damaged vessel. This method is typically used when a smaller (low-flow) artery has narrowed and is incapable of delivering enough blood to the brain.

The most common type of bypass is the STA-MCA (superficial temporal artery to middle cerebral artery) bypass. The superficial temporal artery (STA) normally provides blood to the face and scalp. You can feel the pulse of the STA in front of your ear. The middle cerebral artery (MCA) normally provides blood to the frontal, temporal, and parietal lobes of the brain. Blood flow through the MCA is often reduced when narrowing of the internal carotid artery occurs. In an STA-MCA bypass, the STA (donor vessel) is rerouted from the scalp, passed through a hole in the skull, and connected to the MCA (recipient vessel) above the blockage to restore blood flow to the brain. If the STA is too small or unsuitable, another vessel such as the occipital artery may be used.

Both types of bypasses require creating a hole in the skull to pass the vessel graft or scalp donor artery from outside the skull to the cerebral artery inside the skull. Thus, this surgery is also called an extracranial-intracranial bypass (EC-IC bypass).

Who is a candidate?
You may be a candidate for a bypass if you have:
- an aneurysm, tumor, or atherosclerotic plaque that is not treatable by endovascular or other means
- failure of medication to control TIA symptoms or stroke
- imaging tests (angiogram, CTA, MRA) that show arterial stenosis or occlusion
- cerebral blood flow studies (CT perfusion, PET, or SPECT) that show arterial stenosis is causing insufficient blood flow to the brain

Cerebral bypass may be helpful in restoring blood flow and reducing the risk of stroke in conditions:
- **Moyamoya disease**: a narrowing of the internal carotid arteries at the base of the brain that can cause multiple strokes or hemorrhages. To compensate for the narrowing arteries, the brain creates collateral blood vessels in an attempt to deliver oxygen-rich blood to deprived areas of the brain. A bypass can restore blood flow to the brain and prevent future strokes.
- **Aneurysm**: a bulge or ballooning of an artery wall. Some giant, fusiform, or dissecting aneurysms cannot be treated with surgical clipping or endovascular coiling. In such cases, the parent artery must be sacrificed and the blood flow bypassed for the aneurysm to be effectively treated.
- **Skull base tumor**: a tumor can grow where the major vessels enter the skull and surround or invade the artery. Removing the tumor may require sacrificing the encased artery and bypassing the blood flow.
- **Carotid artery stenosis or occlusion**: a narrowing or blockage of the carotid artery in the neck caused by atherosclerotic plaque deposits in the vessel wall.
- **Intracranial arterial stenosis**: a narrowing or blockage of an artery inside the skull that supplies blood to specific areas within the brain.

Who performs the procedure?
A cerebral bypass is performed by a neurosurgeon. Many neurosurgeons have specialized training in cerebrovascular surgery. Ask your surgeon about his or her training, especially if your case is complex.

What happens before surgery?
Your surgeon may order special tests to aid in planning the bypass surgery, including:
- **Angiography or ultrasound** evaluation of potential graft sites in the legs and arms.
- **Angiography** of the brain vessels to evaluate the blockage and choose the best places to connect the graft.
- **Balloon test occlusion** is used to evaluate whether one artery can be temporarily or permanently blocked without significantly affecting the level of blood in your brain. Performed during an angiogram, a balloon is advanced through a catheter to the artery. The balloon is temporarily inflated to stop blood flow and your condition is monitored. Every few minutes your hand grip, foot flexion and extension, language, memory, and facial expression is checked for signs of weakness. If you have good collateral blood vessels, the other arteries send enough blood to the brain so there is no change in brain function. The balloon is usually left in place for 30 minutes, then deflated and removed. If you lack collateral connections and not enough blood gets to the brain, you may develop weakness in an arm, or difficulty speaking. If this occurs, the balloon is immediately deflated and removed. Once removed, blood flow is restored and the weakness goes away, usually within seconds.

If the pre-surgical test results are positive, you will be scheduled for surgery. In the doctor’s office you will sign consent forms and complete paperwork to inform the surgeon about your medical history, including allergies, medicines, anesthesia reactions, and previous surgeries. You will need to have a complete history and physical exam performed by your primary care physician or in the hospital’s pre-admission testing office prior to surgery. Typically, a blood test, electrocardiogram (EKG), and chest X-ray need to be performed. Discuss all medications (prescription, over-the-counter, and herbal supplements) you are taking with your health care provider. Some medications need to be continued or stopped the day of surgery.

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Stop taking all non-steroidal anti-inflammatory medicines (Naprosyn, Advil, Motrin, Nuprin, Aleve, etc.) 1 week before surgery. Stop smoking, chewing tobacco, and drinking alcohol 1 week before and 2 weeks after surgery because these activities can cause bleeding problems. You may also need to have clearance from your primary care physician or cardiologist if you have a history of other medical or heart conditions.

You may be asked to wash your skin and hair with Hibiclens (CHG) or Dial soap before surgery. It kills bacteria and reduces surgical site infections. (Avoid getting CHG in eyes, ears, nose or genital areas.)

Don’t eat or drink after midnight before surgery (unless the hospital tells you otherwise).

**Morning of surgery**
- No food, drink, gum or candy. You may take permitted medicines with a small sip of water.
- Shower using antibacterial soap. Dress in freshly washed, loose-fitting clothing.
- Wear flat-heeled shoes with closed backs.
- You should take 325mg of aspirin to thin the blood.
- Remove make-up, hairpins, contacts, body piercings, nail polish, etc.
- Leave all valuables and jewelry at home.
- Bring a list of medications with dosages and the times of day usually taken.
- Bring a list of allergies to medication or foods.

Arrive at the hospital 2 hours before your scheduled surgery time to complete the necessary paperwork and pre-procedure work-ups. An anesthesiologist will talk with you and explain the effects of anesthesia and its risks.

**What happens during surgery?**
What happens during surgery varies depending on the type of bypass procedure. Described below is the commonly performed **STA-MCA bypass**. There are 7 steps to the procedure, which generally takes 3 hours.

**Step 1. prepare the patient**
You will lie on your back on the operative table and be given anesthesia. Once asleep, your head is placed in a 3-pin, skull-fixation device, which attaches to the table and holds your head in position during the procedure. The hair near the incision area is shaved and the scalp is prepped with an antiseptic.

**Step 2. make a skin incision**
The surgeon uses Doppler ultrasound to locate and mark the course of the superficial temporal artery (STA) on the scalp with a pen. A skin incision is made along the artery.

**Step 3. prepare the donor artery**
A branch of the STA is carefully dissected from the underlying muscle. After the STA is freed, the muscle is cut and folded back to expose the bone.

**Step 4. perform a craniotomy**
Next, small burr holes are made in the skull with a drill. The burr holes allow entrance of a special saw similar to a jigsaw. The surgeon cuts an outline of a bone window. The bone flap is lifted and removed to expose the protective covering of the brain, called the dura. The dura is opened and folded back to expose the brain.

**Step 5: prepare the recipient artery**
Working under an operating microscope, the surgeon carefully locates a branch of the middle cerebral artery (MCA) suitable for bypass. The size of the recipient vessel must be a good match for the diameter of the donor vessel.

**Step 6. attach donor and recipient arteries**
Temporary clips are placed across the donor and recipient vessels to stop the blood flow. The distal STA is cut and the end prepared for anastomosis. The surgeon then makes an opening in the side of the MCA vessel and sutures the two blood vessels together.

**Step 6. verify blood flow through the bypass**
After the vessels are attached, the surgeon releases the temporary clips and verifies there are no leaks. Using a Doppler ultrasound or special fluorescent dye, good blood flow through the bypass is verified.

![Figure 2. The superficial temporal artery (STA) is routed through a hole in the skull, called a craniotomy, and is connected to the middle cerebral artery (MCA) to restore blood flow to the brain.](image)
Incision Care

Step 7. close the craniotomy
The dura is closed with sutures. The bone flap is replaced, but a hole is enlarged to allow passage of the bypass vessel without kinking or pressure. The bone flap is secured to the skull with titanium plates and screws (Fig. 2). The muscles and skin are sutured back together. A dressing is placed over the incision.

What happens after surgery?
You will wake up in the recovery area. You may have a sore throat from the tube used during surgery to assist your breathing. The breathing tube (ventilator) usually remains in place until you fully recover from the anesthesia. Once awake you will be moved to the neuroscience unit for observation. You will frequently be asked to move your arms, fingers, toes, and legs as part of the neurological exam. You may experience some nausea and headache after surgery; medication can control these symptoms. Patients are encouraged to get out of bed and walk several times a day and are encouraged to eat and drink as tolerated.

The nurse will use a device called a Doppler ultrasound every few hours to check the pulse at your incision site to ensure the new connection between your arteries is working correctly. A CT scan will be performed at some stage after surgery to confirm that no complications have occurred (especially postoperative bleeding). In 1 to 2 days you’ll be released from the hospital. Be sure to have someone at home to help you for the first 24 to 48 hours.

Follow the surgeon’s home care instructions for 2 weeks after surgery or until your follow-up appointment. In general, you can expect:

Restrictions
- Don’t lift anything heavier than 5 pounds.
- No strenuous activity including yard work, housework, and sex.
- Don’t drink alcohol. It thins the blood and increases the risk of bleeding. Also, don’t mix alcohol with pain medicines.
- Don’t smoke or use nicotine products: vape, dip, or chew. It may delay healing.
- Don’t drive, return to work, or fly air travel until your surgeon says it’s Ok.

Incision Care
- You may shower the day after surgery and wash your hair with mild baby shampoo. Gently wash the incision area with soap and water every day. Don’t scrub or let the water beat hard on your incision. Pat dry.
- If Dermabond skin glue covers your incision, don’t rub or pick at the glue.
- Don’t submerge or soak the incision in a bath, pool or tub. Don’t apply lotion/ointment on the incision, including hair styling products.
- You may hear strange noises (popping, crackling, ringing) inside your head. This is normal healing as air and fluid reabsorb.
- Don’t color your hair for 6 weeks. If you cut your hair, use caution near the incision.

Medications
- Headaches are common after surgery. You may take acetaminophen (Tylenol).
- Take pain medicines as directed by your surgeon. Reduce the amount and frequency as your pain subsides. If you don’t need the pain medicine, don’t take it.
- Narcotics can cause constipation. Drink lots of water and eat high-fiber foods. Stool softeners and laxatives can help move the bowels. Colace, Senokot, Dulcolax and Miralax are over-the-counter options.
- Anti-seizure medicine may be prescribed. Some patients develop side effects such as drowsiness, balance problems, or rashes. Call the office if any of these occur.

Activity
- Get up and walk 5-10 minutes every 3-4 hours. Gradually increase walking as you are able.
- Swelling and bruising of the eye or face may occur. It will take several weeks to go away.
- Sleep with your head elevated and apply ice 3-4 times per day for 15-20 minutes to help reduce pain and swelling.

When to Call Your Doctor
- Fever over 101.5º (unrelieved by Tylenol)
- Signs of incision infection, such as spreading redness, separation, or colored drainage.
- Increased drowsiness, weakness of arms / legs, increased headaches, vomiting, or severe neck pain that prevents lowering your chin to chest.
- New or worsening vision, speech or confusion.
- Swelling at the incision with leaking of clear fluid from your ear or nose.
- Swelling and tenderness in the calf of one leg.
- Seizure

Call 911 if you have:
- trouble breathing (blood clot in lung).
- facial droop, slurred speech, arm weakness, confusion (signs of a stroke).
- a sudden severe headache, popping or snapping sensation in the head, nausea and vomiting, or a stiff neck (signs of an aneurysm rupture).

Recovery and prevention
Before you leave the hospital, an appointment with a nurse practitioner will be scheduled 10 to 14 days after surgery to remove your sutures and check your recovery. If you live far away, an arrangement can be made with your primary care physician to have your sutures removed there.
An appointment for a follow-up visit with your neurosurgeon will be scheduled for 2 to 4 weeks after surgery. Follow-up imaging studies are usually scheduled 3 to 6 months after surgery to check that blood flow through the arteries and bypass graft is adequate.

Care must be taken when wearing eyeglasses. There is a risk of damaging the graft if the glasses fit too tightly over your ears in the temple area. You should use gauze to pad the area between your incision and your glasses.

Patients who undergo bypass surgery will take an anti-platelet medication (e.g., aspirin) daily. Anti-platelets thin the blood, allowing blood to flow more easily and preventing clots from forming in the bypass graft. Patients who have stomach problems should use coated aspirin and take it with food. Birth control pills increase the risk of having blood clot problems, and we recommend that bypass patients not use them.

What are the risks?
No surgery is without risks. General complications of any surgery include bleeding, infection, blood clots, and reactions to anesthesia. Specific complications related to cerebral bypass may include:

- **Stroke** can occur from manipulation and temporary clipping of the arteries in the brain. It can also occur from graft failure, or failure of blood to flow adequately though the newly connected arteries.

- **Seizures** are a risk with any brain procedure. You will be given several days of anti-seizure medication after your procedure as a precaution. Seizures can also be caused by a potential but rare complication called a hyper-perfusion injury. Swelling and/or bleeding in the brain can occur in response to an increase in blood flow to brain areas that were formerly receiving very low amounts. Symptoms of hyper-perfusion injury include headache, facial/eye pain, or other neurological deficits.

- **Graft occlusion** occurs when blood clots form inside the donor vessel blocking off the blood flow. This is rare because blood flow measurements at the time of surgery ensure graft patency.

What are the results?
The goal of cerebral bypass surgery is to restore blood flow to the brain and reduce the risk of stroke. The effectiveness of bypass depends on the type of graft used and the underlying condition being treated.

For moyamoya disease, studies have shown a clear benefit from bypass to increase blood flow to low perfused areas in the brain thus decreasing the risk of ischemic stroke [1,2]. The effectiveness of bypass to prevent hemorrhagic stroke is a current topic of research. Some suggest there may be a decreased risk of hemorrhage since the small fragile moyamoya vessels are no longer needed to perfuse the brain. However, reduction in moyamoya vessels is observed in only 25–65% of patients [3].

For aneurysm and tumors, results of bypass vary widely depending on the lesion location and type of bypass graft. Ask your surgeon what results you can expect.

For carotid artery occlusion, the effectiveness of bypass to decrease the risk of ischemic stroke is controversial. The role of bypass surgery for atherosclerotic carotid artery stenosis has been studied in several clinical trials that have failed to confirm a benefit of bypass against best medical treatment [4,5]. However, there are a subset of stroke patients with hemodynamic ischemia, poor collateral circulation, and a high risk for recurrent stroke in which bypass may be an option.

Although bypass surgery improves blood supply to the brain, it doesn't cure underlying carotid artery or cerebrovascular disease. Your results and long-term outcome will depend in part on taking medications as directed and following a healthy lifestyle: stop smoking, eat right, reduce cholesterol, maintain a healthy weight, control blood pressure, manage diabetes, and exercise.

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

Sources
5. Role of and Indications for Bypass Surgery After Carotid Occlusion Surgery Study (COSS)? Stroke 47:282-290, 2016

Links
www.moyamoya.com
Glossary

anastomosis: the connection of normally separate parts or spaces so they intercommunicate, as between two blood vessels.

balloon test occlusion: a test performed during an angiogram in which a balloon is temporarily inflated inside an artery to block the flow of blood. Used to evaluate collateral blood flow to the brain and assess whether a bypass or vessel sacrifice can be safely tolerated.

cerebrovascular insufficiency: an insufficient blood flow to the brain. The most common cause of decreased blood flow is atherosclerosis of the arteries that supply blood to the brain.

collateral vessels: a branch of an artery or vein used as an accessory to the blood vessel from which it arises; often develop to shunt blood around a blockage.

Doppler ultrasound: a noninvasive test that uses reflected sound waves to evaluate blood as it flows through a blood vessel.

EC-IC bypass: acronym stands for extracranial–intracranial bypass procedure in which an artery from outside the skull is attached to an artery inside the skull through a craniotomy.

ischemic stroke: stroke caused by an interruption or blockage of oxygen-rich blood flow to an area of the brain; caused by a blood clot, atherosclerosis, vasospasm or reduced blood pressure.

hemorrhagic stroke: stroke caused by the rupture of a blood vessel in the brain.

occlusion: an obstruction or closure of a passageway or vessel.

perfuse: to force blood or other fluid to flow from the artery through the vascular bed of a tissue.

revascularization: to restore blood supply to an organ by means of a blood vessel graft.

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.