INTRODUCTION

The function of human kidneys which have failed from disease or injury can be assumed by treatments with an artificial kidney. The hemodialysis machine (hemo means blood) removes wastes from the blood stream and regulates the body's fluid and chemical balances. A vascular access device connects the patient’s blood stream, or circulation, to the machine. Blood flows from the patient to the machine, is cleansed, and returned. Temporary access devices are plastic tubes (catheters) which are inserted directly into a large vein. More permanent access is obtained by creating a high flow connection between an artery and a vein, typically in the patient’s arm, which can be hooked up quickly and easily to the dialysis machine.

The circulation consists of a pump (the heart), and blood vessels. Arteries carry blood away from the heart to the tissues at high pressure; veins return blood to the heart at low pressure. Renal arteries and veins typically allow up to one quarter of the heart’s output to flow through the kidneys, roughly one quart per minute. Similarly, the dialysis machine requires a high blood flow (at least one third to one half quart per minute) to replace kidney function.

This chapter answers many of the most common questions patients ask about access devices: what they are, how they work, what to expect during and after the operation, and what can go wrong.

TEMPORARY ACCESS

A temporary access catheter is necessary if dialysis is required before a permanent device has been placed, before it is ready for use, or if it stops functioning. Temporary access is achieved by placing a catheter into a large vein in the groin, under the collarbone, or in the neck. These catheters (often called Quinton catheters) actually contain two separate tubes; one carries blood from the patient to the dialysis machine, and the other returns
blood to the circulation.

These temporary catheters can be inserted in two different ways. Percutaneous placement (inserting the catheter through a puncture in the skin) can be performed in the dialysis unit or a hospital bed. The skin is first cleaned with an antiseptic solution, and the area is surrounded with clean paper sheets to insure sterility. Local anesthesia (lidocaine) is then injected to numb the skin and make the procedure as pain-free as possible. The catheter is placed into a large vein and secured with a stitch.

The second technique uses a slightly larger catheter (a Quinton/Hickman—see Figure 1) and is performed in the operating room. It can frequently be done with local anesthesia alone; sedation or general anesthesia is often used as well. (See “HEMODIALYSIS ACCESS OPERATIONS,” below.) After cleaning the skin and draping, a small incision is made in the neck just above the collarbone. The surgeon locates the internal jugular vein beneath the neck muscles and inserts the catheter directly into it. The catheter is tunneled under the skin and exits the body on the upper portion of the chest. These catheters are usually placed on the right side of the neck. Catheters inserted in this fashion are preferred if longer use is anticipated. They are less likely to become infected and can therefore be used for longer periods of time (weeks or even months) than percutaneously placed catheters.
The Hemodialysis Access

Figure 1
This is an illustration of a tunneled dialysis catheter (Quinton/Hickman catheter). It contains two channels. The tip (at the bottom of the illustration) is placed in a large vein by a surgeon in the operating room. The other end contains two ports which are connected to the dialysis machine. Arrows illustrate the direction of blood flow.

These temporary catheters require regular flushing with heparin to prevent clotting. Despite these measures, clotting and consequent diminished flows are not uncommon. Clotted catheters can often be opened with injections of medicines which dissolve clots (thrombolytic agents). Streptokinase and urokinase are examples.

Clotted catheters that cannot be reopened need to be replaced. In addition, catheters which are left in place too long carry a significant risk of infection. If a patient needs dialysis for an extended time, more permanent access is required.

PERMANENT ACCESS

Permanent access for hemodialysis requires the creation of a high flow connection between an artery and vein. They are typically constructed just beneath the skin to provide a quick and easy connection to the dialysis machine. When it is necessary to connect the patient’s circulation to the dialysis machine, a dialysis nurse places two needles in the access after (optionally) using a small amount of local anesthetic. One needle provides
arterial blood to the dialysis machine, and the other returns blood to the venous side of the circulation. There are two principle types of permanent access: the Cimino fistula and the synthetic graft.

The Cimino fistula is the preferred type of permanent hemodialysis access; it has a lower incidence of clotting and infection than synthetic grafts. Unfortunately Cimino fistulae cannot be made to work for all patients. (A fistula is any abnormal connection between one part of the body and another; in this case the fistula is created between an artery and a vein and is therefore called an arterio-venous fistula. Cimino was the physician who originally described this technique in 1966.) A Cimino fistula is created by joining a large vein directly to an artery, typically in the forearm at the wrist, or higher in the arm near the elbow crease. Figure 2 demonstrates the creation of a Cimino fistula at the wrist using the cephalic vein and the radial artery. This procedure can easily be performed under local anesthesia on an outpatient basis. After local anesthesia has been injected into the skin, the artery and vein are isolated. The vein is then divided, and the end leading up the arm and back to the heart is sewn with fine suture to a hole made in the side of the artery. Blood circulating down the artery flows both up the vein fistula and down into the hand; this arrangement lessens problems with blood flow to the hand. Rarely, coolness and numbness develop in the hand following placement of a Cimino fistula. These symptoms usually improve.
Figure 2
Details of how the Cimino fistula is made. In C the dotted line shows where a slot will be cut in the artery. The cut end of the vein is stitched to it to form the T connection shown in D.

To work effectively, the vein used for the Cimino fistula must be relatively large. About one third of fistulae will fail during the first few weeks because of small or thin veins. Following creation of a Cimino fistula the vein will dilate and its walls will thicken in response to the higher pressure of arterial blood flow. These changes enable the vein to provide the high flows needed for dialysis and to withstand repeated needle punctures. It typically takes 4 to 8 weeks before a newly created Cimino fistula is ready for use.

Since the onset of renal failure and subsequent need for dialysis is often slow, many patients can easily wait for their fistula to mature without requiring temporary access. Since a well functioning fistula depends upon good veins, it is wise for patients who expect dialysis to discourage the use of their forearm veins for blood drawing or the placement of intravenous catheters. (Hand veins can be used without causing a problem.)

If a patient’s veins are too small or thin to use for a Cimino fistula, a synthetic graft can be used. Today, most of these grafts are made from polytetrafluorethylene (PTFE), the same material used for Teflon coatings and Gortex laminates. When used for hemodialysis access, the PTFE graft is
typically a 6 millimeter diameter tube. The tube is tunneled in a loop under the skin and sewn to an artery and vein at the elbow to create a fistula similar in function to the Cimino. See Figure 3 below. Occasionally, if the forearms have been used previously, grafts may be placed in the upper arm or run up to the shoulder.

![Diagram of PTFE graft in the forearm](image)

**Figure 3.**
An under-the-surface view of a PTFE graft in the forearm (the hand is to the right). Blood runs through it from the artery (top) to the vein (below). The graft is used by placing two needles in it, one upstream, one downstream.

It is possible to use local anesthesia to create access with a synthetic graft. The tunneling can be uncomfortable, however, and it is common to use general anesthesia or a nerve block to insure patient comfort. (See “HEMODIALYSIS ACCESS OPERATIONS,” below.) PTFE grafts are rarely placed in the thigh, usually because both arms have been previously used for access. Grafts in the thigh have more problems associated with them than grafts placed in the arm.

**HEMODIALYSIS ACCESS OPERATIONS**

The placement of a tunneled temporary access catheter, Cimino fistula, or PTFE graft takes place in the operating room. Anesthesia is used to make the procedure comfortable for the patient. The form of anesthesia is chosen by the patient, the surgeon and the anesthesiologist. Selection of the appropriate anesthetic depends upon the patient’s needs, medical problems, and the type of access procedure performed.
Local anesthesia uses lidocaine to numb the skin. Although the medicine burns or stings when it is first injected, it allows many procedures to be performed with little or no discomfort. Cimino fistulae are often placed with local anesthesia alone. There is minimal recovery time required, and the patient usually goes home soon after surgery.

Intravenous (IV) sedation uses medicines injected through an IV catheter into the blood stream to relax the patient. These medicines often make the patient quite sleepy. An anesthesiologist is needed to give these medicines and to monitor the patient during the procedure. A short recovery time is required to allow them to wear off.

A brachial nerve block is performed by an anesthesiologist to make the patient’s entire arm numb. Lidocaine is injected around the nerves which supply the arm and transmit sensation to the brain. The injections are made in the arm pit or around the collarbone. Occasionally the block works only partially and local anesthesia or IV sedation is also required. The block requires several hours to wear off.

General anesthesia uses intravenous medicines and inhaled gases to make the patient unconscious during the procedure. It usually requires that a breathing tube be placed in the trachea or windpipe after the patient “goes to sleep.” General anesthesia requires the longest recovery period.

Unless the operation is performed with local anesthesia only, the patient should not eat or drink anything after midnight the day before the procedure. If there is uncertainty as to what form of anesthesia will be used, it is best to keep the stomach empty. Prescription medicines, however, should usually be taken at their usual time with a small sip of water. The patient should check with the surgeon or anesthesiologist to decide which medicines to take before the operation.

Many access procedures can be done on an outpatient basis; that is, the patient comes to the hospital on the day of surgery and leaves several hours after the operation. In general, it is necessary to have some one come to the hospital with you if you are going home the same day unless a straight local anesthetic is used. It is common for people having PTFE grafts placed to stay in the hospital for a day or two to allow the surgeon to keep
an eye on the graft. In addition, the patient’s medical problems may make a stay in the hospital necessary.

In the operating room the patient lies on the operating table. In addition to the surgeon, an anesthesiologist and surgical assistants may be in the room. There are usually two nurses present: one hands instruments to the surgeon; the other helps insure that the patient is comfortable and that the procedure runs smoothly. The region of the body where the surgery will take place (the arm, for example) is cleaned with an antiseptic solution, sterile drapes are then used to ensure that everything touched by the surgeon is absolutely clean. After the operation, a bandage is placed over the incision(s), and the patient is taken to the recovery room. Many Cimino fistulae can be created with one incision; placement of a PTFE graft requires several small incisions.

**AFTER THE OPERATION**

If the access procedure has been performed in the arm it is important to keep it elevated to reduce swelling and discomfort. Ideally, the region operated on should be kept above the level of the heart as much as possible. The incision should be kept dry for two days. After this period, the bandage can be removed, and the area can be gently washed with soap and water. Avoid scrubbing the incision or soaking it until the sutures have been removed. A bandage is not necessary after the original one has been removed as long as the area is kept clean and dry. Stitches can be taken out in about ten days by the surgeon, a family doctor, or a dialysis nurse.

The incision may be sore for several days after the operation. Again, keeping the arm elevated is very important. Many people find that they require only acetaminophen (Tylenol™, and others) or ibuprofen (Advil™, and others) for adequate relief. Your surgeon will often give you a prescription for stronger pain medicine to have available if you should need it.

Light activity is safe after an access procedure as long as it does not cause discomfort. Heavy work is not advisable, and you should also avoid putting pressure on the graft or fistula.
Some pain, swelling, redness, and bleeding after an operation is normal and should improve over several days. If these problems get worse rather than getting better, you should contact your surgeon or your dialysis doctor. You should also call your doctor if you have a fever (temperature greater than 101°F).

Both Cimino fistulae and PTFE grafts require several weeks to mature before they can be used for dialysis. If a Cimino fistula is used, the vein needs to become larger and thicker. If a PTFE graft is used, the tissue around the graft needs to heal and incorporate the graft. If dialysis is needed in the meantime, a temporary access catheter can be used. When the permanent access device is ready to use, two needles are placed through the skin and into the vein or the PTFE graft. One needle receives arterial blood flow, the other returns blood to the venous side of the circulation. These needles are connected by plastic tubes to the dialysis machine. After dialysis, the needles are removed and small bandages are placed over the puncture sites to prevent bleeding. These bandages should not be too tight and should not encircle the arm. Do not press tightly on the access to stop the bleeding unless the bleeding is very brisk. It is important that the needles be placed into different locations in the access for each dialysis treatment to avoid creating a large hole in the fistula or graft. Careful attention to the technique used to connect to the access will keep it working longer.

Your access will last longer if you avoid wearing restrictive clothing on the arm containing the access. Do not allow anyone to draw blood from or allow blood pressures to be taken on the arm containing the access.

**ACCESS PROBLEMS**

**Clotted Access.** The most common problem experienced with dialysis access devices is clotting, or thrombosis. Blood clots can form in temporary access catheters, Cimino fistulae, and PTFE grafts. Clotting can decrease or stop blood flow and make dialysis impossible.

As mentioned previously, clotted temporary catheters are injected with special thrombolytic agents or are replaced.
Clotting is a more common problem for PTFE grafts than for Cimino fistulae. (Blood is stimulated to clot by artificial substances; blood vessel walls contain substances that help to prevent clotting.) It is usually possible to tell by examining a fistula or graft if there is good flow through it. Good flow is turbulent and often produces a rhythmic buzz or thrill. If a previously appreciated thrill is gone, it usually means that flow has diminished significantly. The access should be checked three times a day, especially in the morning, to insure that there is still flow. If it appears that the device has stopped working, notify your dialysis doctor or your surgeon. Clotting occurs more frequently in the summer months when patients are more likely to become dehydrated and flow through the access device decreases.

A clotted fistula or graft is typically fixed in the operating room. Removing the clot is known as a thrombectomy. Anesthesia is usually local with IV sedation, or a brachial block (see “HEMODIALYSIS ACCESS OPERATIONS,” above). The surgeon makes a small incision into the graft and uses a special catheter to remove clots and restore flow. If this is successful, the surgeon repairs the incisions with several stitches and the operation is complete. Sometimes an obstruction forms which cannot be fixed with this technique, and the graft needs to be repaired by bypassing the obstruction with another segment of PTFE graft. Rarely, grafts cannot be successfully repaired and a new graft is needed. This happens most frequently as grafts become older and undergo more frequent repair.

In some cases it is possible to use thrombolytic agents to dissolve the clot. newer grafts are more successfully treated with this technique.

Infection. All access devices can become infected. A Cimino fistula, because it does not introduce foreign material into the body, is only very rarely infected. Bacteria can be introduced when needles pass through the skin and into the graft. If bacteria become adherent to graft material it is difficult for the body’s defenses to control and eliminate infection. Signs of infection can be local or systemic. Local signs include redness, tenderness, and swelling over the graft. Systemic, or generalized symptoms of infection, include fever, chills, and a washed out, achy feeling. When these signs and symptoms are present it is important to be seen by a doctor to be sure that an infection is not present. If the graft appears to be infected, it can
sometimes be treated with antibiotics alone. Most serious infections require removal of the infected device in addition to treatment with appropriate antibiotics.

**Bleeding.** Significant bleeding is a very rare problem. It usually occurs after a graft or fistula has become weakened by repeated punctures in the same area. Bleeding is always controllable by placing direct pressure at the site of the bleeding. Stopping the bleeding is more important than preserving flow in the graft or fistula. After the bleeding has been controlled you should call your surgeon and go to the hospital.

**CONCLUSION**

Every year more individuals enter dialysis, and the time on dialysis lengthens for many others. Although a good proportion of access devices may function well for prolonged periods without difficulty, others may begin to wear out or function so poorly that a bypass or replacement becomes necessary. Knowledge and careful attention can help to extend the useful life of these devices and minimize access problems.