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IMAGING

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Dialysis Access

- Care of dialysis patients is complex and requires close collaboration among caregivers, including nephrologists, interventional radiologists, and surgeons.
- An arterio-venous fistula (AVF) is the preferred method of vascular access because it can last for several years and infection risk is low.
- AVFs take several weeks to mature, and a central venous catheter may be necessary to initiate dialysis.
- Alternate access systems include arteriovenous grafts (AGF), hemodialysis reliable outflow (HeRO®) grafts, and peritoneal catheters.
- All access routes must be regularly monitored, and problems such as thrombosis and stenosis must be addressed to maintain function.

Patients with end-stage renal disease require long-term complex care, which is best handled by a cooperative team of nephrologists, interventional radiologists, surgeons, and specialty nurses. Several options are available for dialysis access, including arteriovenous fistula (AVF), tunneled central vein access (CVA), arteriovenous graft (AVG), hemodialysis reliable outflow (HeRO®) graft, and peritoneal access. Each patient must be evaluated to determine his or her needs. Once the access route is established, it must be routinely monitored to maintain a suitable flow rate and identify problems, such as thrombosis and infection, which can be addressed by a number of interventions.

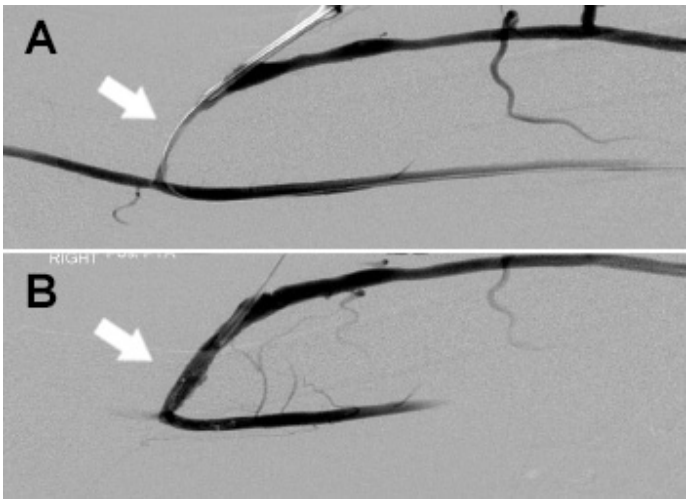

Figure 1. Fistulogram showed severe juxta-anastomotic stenosis (arrow)**(A)**. Stenosis was completely resolved after angioplasty (arrow)**(B)**.

Arteriovenous Fistula (AVF)

An AVF is the preferred method of access because it lasts longer than other access routes (3-7 years) and is less prone to infection and thrombosis. Ideally, if there is sufficient notice that dialysis will be necessary, an AVF can be created and allowed to mature in advance. However, as an AVF takes 2–3 months to mature, lead time is insufficient in many cases of kidney failure, and immediate access is required. Such access is usually achieved by an image-guided procedure in which a catheter is tunneled under the skin for a few inches before placing a CVA into a central vein. Although tunneling reduces the risk of infection, a CVA route is more likely to become infected than other access routes. CVA is also associated with central vein stenosis and increased mortality risk. For these reasons, CVA is regarded as a temporary solution while another access route is developed.

The first step in preparing for an AVF is to map blood vessels in the arm with either ultrasound or venography to determine the best placement of the fistula, which a surgeon then creates. Veins are not adapted for the high pressure of arterial blood. Over the next few weeks, the wall thickens in response to arterial pressure, and the vessel widens. The AVF is closely monitored over the next few weeks to determine whether it matures and is suitable for dialysis. If not, corrective procedures are performed under image guidance.

To be suitable for dialysis, blood flow through the fistula must be between 600 and 1,000 mL/min. If the flow rate is too low, the fistula will not be effective for dialysis and will become prone to thrombosis. If it is too high, the high

degree of recirculation makes it ineffective for dialysis.

If flow rates exceed 2,000 mL/min, blood flow to the hand is insufficient (steal syndrome) and the heart becomes strained, which can lead to cardiac failure.

Several problems may reveal themselves, both during the maturation process and subsequently. For example, a stenosis may develop, which is especially likely at the site where the artery and vein have been connected. Neoplasia may result in narrowing of the lumen of the vein. These problems may be addressed by balloon angioplasty. Conversely, blood flow through the fistula may be diminished because of blood flow through collaterals, which may be resolved by a ligation procedure to block collateral blood flow. A third common problem results from excessive vein expansion, resulting in very high blood flow. In this case, interventional radiologists employ a banding procedure to reduce flow. In some cases, despite interventions, AVFs fail to mature and cannot be used for dialysis.

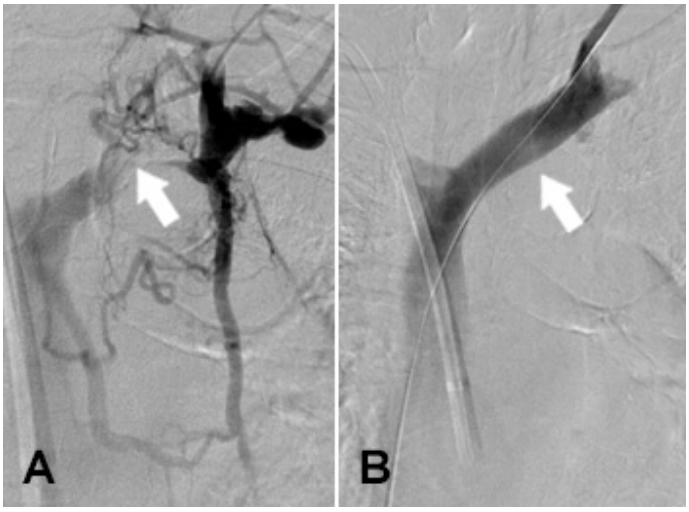

Figure 2. Patient presented with facial swelling. Central venogram showed left brachiocephalic vein occlusion (arrow) (A). After angioplasty, left brachiocephalic vein was widely patent (arrow), and facial swelling was resolved **(B)**.

Arteriovenous Graft (AGF)

Although AVF is regarded as the preferred method, it can be very challenging to create a successful AVF in some patients. For example, age-associated vascular changes and co-morbidities in elderly patients (≥ 75 years) can limit the success rate of AVF creation.

Placing an AGF is a surgical procedure in which an artery and a vein are connected using synthetic tubing. AGFs take less time to heal and mature than AVFs, becoming ready for dialysis is less than half the time and minimizing the time that patients are dependent on a CVA, with its associated problems. However, AGFs are more prone to thrombosis than AVFs because of the synthetic material, and they require more interventions to maintain their patency. In addition, patients in the AGF have a greater chance of developing excessively high flow rates, causing a steal syndrome (peripheral ischemia), which requires management with banding procedures. AGFs usually last about 18 months, which is considerably less than the life expectancy of an AVF.

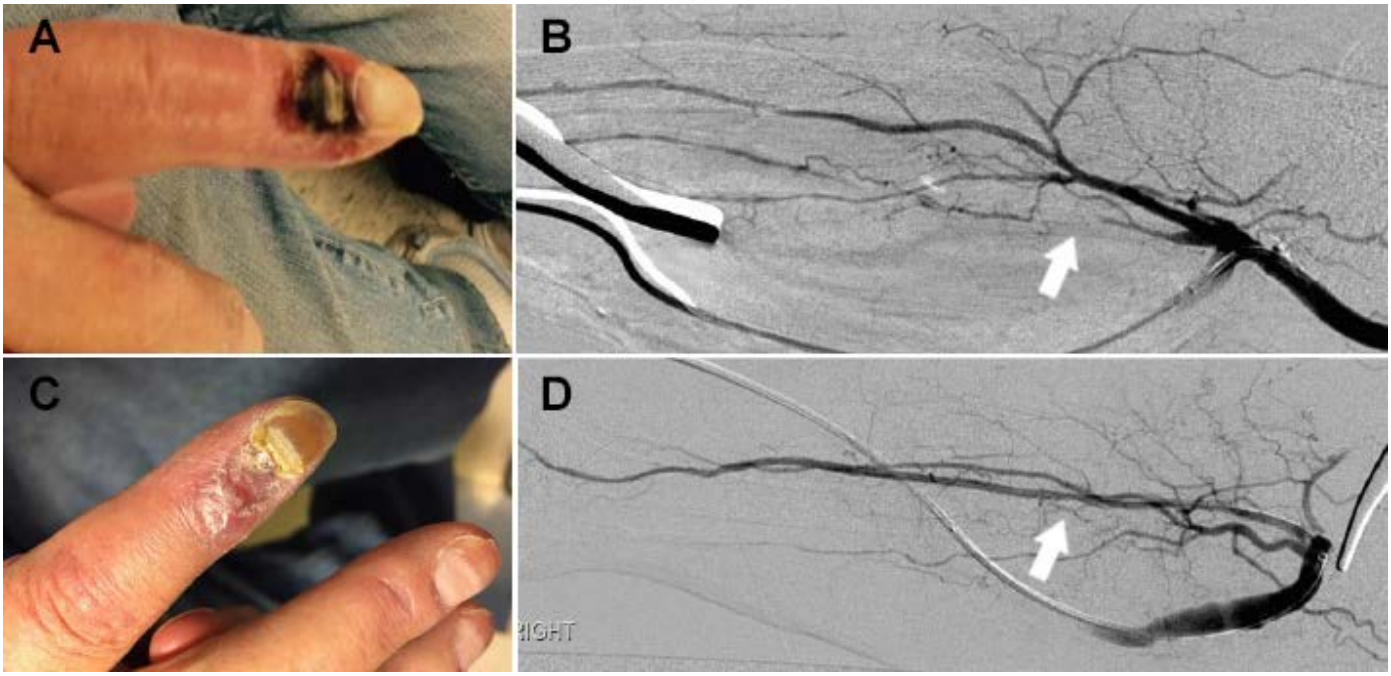

Figure 3. Patient with a right upper extremity graft presented with right 2nd finger ulcer **(A)**. Fistulogram showed occluded radial artery (arrow)**(B)**, which was angioplastied (arrow). Patient ulcer healed after radial artery recannalization **(C, D)**.

Hemodialysis Reliable Outflow (HeRO®) Graft

Patients who have been on dialysis for several years and patients who don't have suitable veins may have difficulty maintaining access with either an AGF or an AVF. In these cases, it is possible to place a hemodialysis reliable outflow (HeRO®) graft. In this procedure, an outflow tube is inserted under image guidance directly into a large neck vein and passed through the vein beyond any blockages that have caused problems. A separate standard dialysis graft is inserted into an artery and is connected to the outflow component. Once in place, blood flows from the artery through the outflow component directly into the heart, providing a highly reliable access route. Furthermore, as the implants are all under the skin, the risk of infection is much lower than a standard CVA.

Scheduling

At Massachusetts General Hospital, care of dialysis patients is coordinated by the Dialysis Access Program, a multidisciplinary program founded in 2003 that includes interventional radiologists, nephrologists, surgeons, and a nurse coordinator. Appointments can be made by calling 617-643-0765.

Further Information

For further information on the Mass General Dialysis Vascular Access Program, please contact Zubin Irani, MD, Interventional Radiology, Department of Radiology at 617-643-4723; or Jie Cui, MD, Renal Associates, Department of Medicine, Massachusetts General Hospital, at 617-643-0765.

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