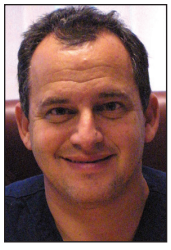
High-Flow Versus Low-Flow Steal and the Hemodialysis Patient

A dialysis access expert weighs in on recognizing and managing this clinical presentation.

WITH SCOTT S. BERMAN, MD, MHA, FACS



Would you explain the concept of arterial steal?

Normal arterial flow down an extremity involves the high-resistance muscular arteries and arterioles distributing flow into the tissue bed through the capillaries. In addition to the main axial arteries, there are collateral pathways between the axillary and proximal brachial arteries in the upper arm and the radial, ulnar, and interosseous arteries (antebrachial arteries) in the forearm. The presence of an arteriovenous fistula (AVF) or arteriovenous graft (AVG) introduces an alternative, low-resistance pathway for the blood flow to take. Not only does a portion of the antegrade flow through the brachial artery get diverted through the AVF or AVG, but some flow that reaches the proximal antebrachial arteries via the collaterals is diverted through the AVF/AVG. This results in the actual reversal of flow in the artery distal to the arterial anastomosis of the AVG/AVF. This defines the physiology of arterial steal and is present in as many as 80% of patients with an AVF or AVG.

What are the symptoms?

Most patients with steal are asymptomatic. Symptoms can range from mild pain, numbness, or coldness during dialysis treatments (typically when systolic blood pressure trends lower than the patient's baseline) to severe pain, paralysis, and/or ischemic ulcers.

What are the degrees of arterial steal?

The most recent classification system for arterial steal was the product of the 2016 Charing Cross Vascular Access Master Class. This system uses a five-level grading classification based on signs, symptoms, and the results of investigations. Other published grading systems use four levels based on symptoms. The simplest classification is:

1. Mild pain, coolness, and/or paresthesia that occurs only during dialysis and is easily tolerated or controlled with a glove.
2. Moderate pain and/or paresthesia/weakness that requires pharmacologic management and occurrence is unrelated to dialysis treatments. These patients may improve with physical therapy and other conservative measures or may require surgical intervention if the symptoms are refractory to less invasive treatment.
3. Severe pain and/or neurologic symptoms that are debilitating to the patient. In the absence of these symptoms, the occurrence of ischemic tissue loss is also considered severe. Patients with this level of steal require surgical intervention to either relieve symptoms or preserve tissue/limb function.

> It is critical to make sure patients and their caregivers understand the urgency in the need for prompt and thorough evaluation of the symptoms of hand pain, paralysis, and/or severe paresthesia should they occur in the immediate postoperative period after AVF or AVG creation.

What are the risk factors for developing arterial steal? Are there any preoperative criteria that can accurately predict the development of significant arterial steal?

The most consistent risk factors for the development of significant steal are diabetes, female gender, and having a brachial-artery–based AVG. In addition to these risk factors, any patient with arterial occlusive disease in the extremity planned to be used for the access would be at risk. Our group (S. S. Berman, MD, unpublished data, 2002)

and the Norfolk group also identified that a digital brachial index measured in the access extremity of < 0.45 at the time of construction has a correlation with the subsequent development of clinically significant steal.[1]

How often does arterial steal require a surgical intervention?

Clinically significant steal requiring an intervention occurs in 5% to 10% of patients.

What diagnostic testing do you perform for arterial steal?

My approach to all patients who manifest steal symptoms includes a duplex scan of the AVF/AVG to measure flow and look for any possible abnormalities in the access circuit, measurement of digital brachial index with and without compression of the access to quantify the level of access-related ischemia, and a detailed arterial duplex scan of the extremity to evaluate and map out the arterial inflow and arterial runoff vessels.

In addition, catheter-based arteriography of the extremity and the access is performed at the time of surgical intervention to correct the steal to both verify the anatomy and document improved perfusion after the intervention.

How do you differentiate between high-flow and low-flow steal? Why is this so critical to the proper treatment choice?

Differentiating high-flow from low-flow steal is based upon the flow in the access. There is no consistent agreement concerning methodologies to measure flow. We use duplex scanning because modern imaging systems contain algorithms to measure volumetric flow. For an AVF, the threshold value that separates high flow from low flow is 600 mL/min. For an AVG, that value is 800 mL/min.

The reason to make this distinction is somewhat intuitive. Access patency is related to flow. Using a flow-reduction procedure such as banding or revision using distal inflow (RUDI) on an access that already has marginal flow may indeed correct the steal, but has a high likelihood to lead to access thrombosis. As part of the workup for steal, it is critical to rule out arterial inflow lesions that could not only be contributing to steal, but also be responsible for a low-flow access.

What are the best treatments for high-flow and low-flow steal?

The available treatments for steal include:

1. *Access ligation:* This is clearly the most effective treatment in reversing the ischemia independent of low flow or high flow, but it creates the secondary challenge of creating a new access for the patient.
2. *Distal radial artery ligation:* Indicated for distal radiocephalic AVFs, where the steal is uniquely a result of flow reversal in the radial artery distal to the AVF.
3. *Distal revascularization interval ligation (DRIL):* Because this procedure does not impact the access flow, it is the treatment of choice for low-flow–related steal. Additionally, because the DRIL includes a bypass into the forearm branches of the radial, ulnar, or interosseous arteries, it is also the treatment of choice for patients who have severe occlusive disease in the proximal portion of these vessels as a contributing factor.
4. *Banding of the access:* This technique is only effective in high-flow–related steal. There is a myriad of techniques reported, including a simple suture placed around the proximal AVF with a 4 mm balloon in place to act as a mandrel for sizing, and the use of expanded polytetrafluoroethylene cuffs. Banding is most consistently successful when performed concurrently with access flow measurements to minimize the risk of reducing the access flow below a critical threshold and thereby minimizing the risk of access thrombosis.
5. *RUDI:* This is an effective treatment for high-flow steal because it moves the inflow of the AVF/AVG to a smaller, more distal artery.
6. *Proximalization of the arterial inflow (PAI):* This is also an effective treatment for low-flow or high-flow steal. PAI moves the inflow to the proximal brachial or axillary artery; therefore, there is no reduction of flow to the access. Moreover, by moving the inflow to the axilla, PAI also reduces the flow reversal in the distal forearm related to the proximity of these vessels and the elbow-based inflow.

If you band a low-flow steal, what is the consequence?

Banding a low-flow AVG/AVF has two potential consequences: too much banding, and the access will thrombose; or not enough banding, and the steal symptoms will persist.

If you DRIL a high-flow steal, what is the consequence?

Doing a DRIL procedure on a high-flow AVG/AVF is usually of no consequence because the access flow is unaffected; however, three factors are critical:

1. The inflow of the DRIL is positioned far enough away from the access (5 to 7 cm) to minimize steal physiology through the DRIL.
2. The distal anastomosis of the DRIL bypass goes to the dominant forearm artery feeding the hand.
3. The ligation component of the DRIL should be proximal to the termination of the radial/ulnar collaterals so that these vessels do not continue to demonstrate steal physiology during intraoperative imaging.

What are some other causes of diminished blood flow to the hand?

The most common cause of diminished blood flow to the hands in the renal failure population is arterial occlusive disease. The DRIL offers the opportunity to bypass these occlusions if there is an acceptable distal target (radial, ulnar, or interosseous artery) feeding the hand. Contemporary minimally invasive revascularization techniques (balloon angioplasty and atherectomy) are finding some application in this setting in improving blood flow to the hand by directly addressing the occlusive disease either alone or concurrently with other techniques to treat steal.

Are there any other questions we should have asked you? Are there any other tips to share?

In the context of vascular access–related steal, one of the most difficult problems is distinguishing that diagnosis from ischemic monomelic neuropathy. Ischemic monomelic neuropathy usually occurs immediately after access creation, and its symptoms are like steal in the absence of measurable ischemia. Unfortunately, in most cases, the only treatment is ligating the access. It is therefore critical to make sure patients and their caregivers understand the urgency in the need for prompt and thorough evaluation of the symptoms of hand pain, paralysis, and/or severe paresthesia should they occur in the immediate postoperative period after AVF or AVG creation.

It is also imperative, given the incidence of diabetes, neuropathy, and peripheral artery disease in the renal failure population that access surgeons carefully evaluate and document preoperative vascular, motor, and sensory function of a patient's hand so that early detection of access-related pathology can be enhanced.

An additional pathology that can add to diagnostic confusion in this setting is carpal tunnel syndrome. Because access ligation or revascularization is not helpful in this setting and would result in the unnecessary sacrifice of the AVF/AVG, it is imperative to exclude the diagnosis of carpal tunnel syndrome in any patient who develops pain and/or neurologic symptoms in the hand after access creation. ■

1. Goff CD, Sato DT, Bloch PH, et al. Steal syndrome complicating hemodialysis access procedures: can it be predicted? Ann Vasc Surg. 2000;14:138–144.

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