Distal Revascularization and Interval Ligation: A Primer for the Vascular and Interventional Radiologist

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ABSTRACT

Dialysis-associated steal syndrome is a clinically significant complication associated with the creation of dialysis grafts or fistulae. The distal revascularization and interval ligation (DRIL) procedure is a surgical procedure, which has been used to treat patients with hand ischemia secondary to arterial “steal” from dialysis accesses. This article will review the dialysis-associated steal syndrome and the history, anatomy, and clinical results of the DRIL procedure.

KEYWORDS: DRIL, distal revascularization and interval ligation, dialysis, arterial steal, hand ischemia

Objectives: Upon completion of this article, the reader should be able to explain the history and management of dialysis-associated steal syndrome.

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In the United States, over 400,000 patients have end-stage renal disease (ESRD).^{1–7} Dialysis-associated steal syndrome occurs when distal arterial ischemic symptoms develop secondary to the placement of arteriovenous grafts or fistulas. In essence, the more proximal dialysis access “steals” the arterial inflow through the low-resistance shunt, creating arterial insufficiency to the extremity, which can lead to symptoms of claudication, numbness, paresthesia, motor dysfunction, pain, or tissue loss. Additionally, the dialysis access can exacerbate these ischemic symptoms by reversing the flow in native artery away from the

forearm and hand.⁸ The lack of sufficient collaterals is an additional factor that contributes to the development of ischemic symptoms in the hand and fingers.⁸ The development of hand ischemia that requires further surgical intervention is between 5 to 8%.^{1–7,9,10} Many surgical options have been described for the treatment of dialysis-associated arterial steal syndrome. The distal revascularization interval ligation (DRIL) procedure has quickly become a desirable treatment option for dialysis-associated arterial steal syndrome. The DRIL procedure has been shown to have a high clinical success rate. Additionally, the existing dialysis

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access is not sacrificed and can continue to be used, thus, a new dialysis access site does not need to be created. Given the clinical importance of this syndrome, interventional radiologists who participate in the care of dialysis patients should be familiar with this procedure.

Many risk factors for the development of dialysis-associated steal syndrome have been described. A history of access-related hand ischemia and diabetes are two of the strongest predictors for the development of subsequent arterial insufficiency to the extremity.¹ Steal is more likely when the access is placed above the brachial artery trifurcation.^{9,10} Other risk factors such as advanced age, female sex, peripheral arterial occlusive disease, large conduits such as femoral or popliteal veins, or history of multiple prior procedures have also been described.^{1,3-5,11} During the placement of the initial dialysis access, an intraoperative digital-brachial index of less than 0.45 is also a risk factor for the subsequent development of hand ischemia.¹² The clinical workup for patients suspected of having arterial steal syndrome includes a physical examination, sonographic Doppler interrogation, and angiography.

ANGRIOGRAPHIC EVALUATION

Initially, patients with symptoms and physical findings that may be attributable to ischemic steal syndrome are evaluated with a sonographic Doppler examination. Patients with abnormal Doppler examinations proceed to angiography for further evaluation. Angiography is performed as the arterial insufficiency may be due to a proximal arterial lesion, which may be amenable to angioplasty, stenting, or surgical bypass. Similarly, a lesion distal to the takeoff of the dialysis access may be amenable to a percutaneous intervention to improve flow to the hand.

The angiographic evaluation is performed from a puncture of the groin and the inflow artery is evaluated from the aortic arch to the hand. A runoff of the forearm and hand are performed initially in a standard anatomic position. The runoff is repeated with extrinsic manual compression of the dialysis access to see if arterial inflow to the forearm and hand improves as evidence of "steal" as the etiology to ischemic symptoms (Fig. 1). Angiography is not performed through a puncture of the dialysis access with the retrograde placement of a catheter into the proximal inflow artery. The catheter that crosses the arterial anastomosis may artifactually cause increased flow to the hand by increasing resistance at the arterial anastomosis. Subsequently, the difference of arterial flow during the baseline and provocative angiograms may be less apparent and underestimate the actual degree of arterial steal.

Figure 1 Angiogram of the left upper extremity performed through a groin puncture. (A) Arterial inflow is seen in the feeding brachial artery and prompt filling of the brachiocephalic fistula. (B) Delayed image shows very little antegrade flow down the forearm vessels. (C) When the fistula is manually compressed, there is significantly better perfusion of the forearm, suggesting a significant amount of dialysis access "steal."

THE DRIL PROCEDURE

If the patient has a flow-limiting stenosis in the arterial inflow to the arm proximal to the takeoff of the dialysis access or distally in the forearm, an endovascular intervention with angioplasty and/or stenting should be attempted in suitable lesions. If the lesion is not amenable to endovascular treatment, surgical bypass could be attempted to increase flow to the hand.

If the dialysis access is truly stealing flow from the hand, additional therapeutic interventions are needed. The definitive treatment to relieve dialysis access steal is to ligate the fistula or graft, which would return arterial inflow to the hand back to the patient's baseline. However, the ligation of fistulas or grafts poses a serious problem for dialysis patients, as a new dialysis access will need to be created. The patient may also end up with a tunneled catheter insertion, which would serve as a bridge until a new access can be created. If the patient has exhausted all other potential sites for the creation of a graft or fistula, the patient may become dependent on a catheter for dialysis.

The ideal surgical treatment would be one that relieved the ischemic symptoms without sacrificing the dialysis access site. Many treatments have been described; however, the DRIL procedure seems to have the best clinical results at this time. In the DRIL

Figure 2 (A) An illustration of the normal preoperative anatomy of a brachiocephalic fistula. The arterial inflow from the proximal native brachial artery (P) and the native artery just distal to the take off of the fistula (D) are indicated. The dialysis access (DA) is also illustrated. (B) An illustration of the distal revascularization and interval ligation (DRIL) procedure anatomy shows the native artery has been ligated just distal to the take off of the dialysis access (DA). The bypass conduit from the native brachial artery to the brachial artery just distal to the ligation of the native artery is demonstrated (diamond pattern).

procedure, the native artery just distal to the arterial anastomosis of the graft or fistula is ligated. Then, an arterial bypass is placed from the native brachial artery, proximal to the takeoff of the dialysis access, to an insertion site into the native artery just distal to the previously described ligation (Figs. 2 and 3).

The procedure was originally described by Schanzer et al in 1988 after a small case series of three patients.¹²⁻¹⁶ Schanzer later published a series of 14 cases in 1992 and 23 cases in 1996. In the last series, all 23 patients showed clinical improvement of their dialysis-associated ischemic symptoms and demonstrated a 95.6% patency at 2 years.¹² In 1994, Tynan-Cuisinier and Berman coined the acronym DRIL.¹² At that time, they published the largest series of patients and showed a 90% relief of symptoms with healing of ulcers or ischemic lesions. They also demonstrated a 12-month patency of 40 to 50% when grafts were used and 80% patency when native veins were used. The DRIL showed a 48-month patency of 80%. Illig et al¹⁷ determined that the increase of flow to the forearm was due to increased pressure at the point where flow splits to supply the forearm and the access. The increase in pressure at the “split point” is secondary to a relative increase in resistance through the artery supplying the access.^{12,17} Functionally, this anatomy allows more flow down the lower resistance DRIL bypass to the forearm.

The proximal anastomosis for the DRIL bypass is placed greater than or equal to 7 cm proximal to the

Figure 3 The angiographic anatomy of a typical distal revascularization and interval ligation (DRIL) bypass. An angiogram was performed after accessing the brachiocephalic fistula in a retrograde fashion. (A) The initial image shows the catheter entering the dialysis fistula and the catheter tip is in the native brachial artery. (B) The catheter was advanced into the DRIL bypass showing opacification of the bypass vein graft. (C) With the catheter tip at the distal anastomosis, arterial inflow via the ulnar artery and interosseous artery are demonstrated. The radial artery is occluded proximally. (D) The distal runoff to the hand shows the ulnar artery is the dominant supply to the hand.

takeoff of the dialysis access.¹ The native brachial artery is ligated just after the takeoff of the dialysis access. The distal anastomosis of the DRIL bypass is inserted in the native artery in an end-to-end or end-to-side fashion just distally to the ligated native artery (Figs. 2 and 3). The greater saphenous vein is used preferentially for the bypass conduit. Other choices would include an arm vein, femoral vein, or cadaveric vein. Using a prosthetic graft is generally the last option.¹

Recently, Huber et al¹ reported the largest series of DRIL cases describing 64 procedures in 61 patients. A DRIL was performed on 19% of the cases less than 24 hours after the initial creation of the dialysis access. The majority of the DRIL creations (44%) were performed greater than 30 days after the initial dialysis access placement.¹ The DRIL relieved symptoms in 78% of the cases. The perioperative mortality was 3% and the complication rate was 22%, with wound infection the most common accounting for 14%. Primary patency

rates of 77%, 74%, and 71% and secondary patency rates of 81%, 76%, and 76% were achieved at 1, 3, and 5 years, respectively. In this series, all dialysis accesses that were functional at the time of the DRIL surgery were used continually for dialysis.¹ The results are comparable to the results from 10 other published DRIL series that were reviewed in the article by Huber et al.¹

The DRIL procedure has been shown to have a good clinical success rate and low complication rate. The high patency rates are likely due to a combination of the short length of the bypass conduit and the location of the arterial inflow. An additional advantage of the procedure is that the dialysis access can continue to be used in an uninterrupted fashion after surgery. The dialysis access is not sacrificed and catheter placement for dialysis is avoided.

One of the main disadvantages of the DRIL procedure is that the native artery is ligated and perfusion to the forearm and hand are dependent on a bypass conduit and potentially collaterals. Despite this concern, no cases of limb ischemia secondary to bypass graft failure have been reported.¹² A high long-term mortality rate has been described in patients who have undergone a DRIL procedure for hand ischemia. Huber et al demonstrated 71%, 59%, and 33% 1-, 3-, and 5-year survival rates with a median survival of 43 months.¹ Yu et al reported that 58% of their patients who underwent this procedure died at a median follow-up of 50 months.¹⁸ The high mortality rate in this subset of dialysis patients presumably is associated with advanced diabetic vascular disease, which leads to a limited life expectancy.¹⁸ The management of patients who develop thrombosis of their DRIL shunt is uncertain. The thrombosed shunts are typically abandoned or surgically revised.

ADDITIONAL TREATMENT OPTIONS

The DRIL is one of the more aggressive surgical options that has been used to treat dialysis associated steal syndrome. Many other surgical options have been described. The revision using distal inflow procedure (RUDI) was described by Minion et al.¹⁹ In the RUDI, the dialysis access is ligated proximally just after the arterial anastomosis. A bypass graft is created from a smaller more distal artery such as a radial or ulnar to the dialysis access (Fig. 4). This anatomy leaves the perfusion to the forearm and hand intact and only potentially places the dialysis access at risk if the bypass occludes.^{1,12,19}

Proximalization of the arterial inflow is another procedure that has been described, which is performed by moving the arterial anastomosis proximally from the brachial artery to the axillary artery by using a bypass graft.^{12,20,21} The more proximal arterial anastomosis should increase the flow to the forearm by increasing pressure at the split point between the arm and the

Figure 4 An illustration of the revision using distal inflow (RUDI) procedure. The proximal arterial inflow (P) and the artery distal (D) to the dialysis access (DA) are shown. The dialysis access (DA) is ligated and a new conduit is made from a small artery in the forearm to the dialysis access.

dialysis access. As the arterial anastomosis is higher in the arm, collateral flow begins at a higher point in the arm, which should also be advantageous to help prevent ischemic symptoms to the hand.²⁰ The surgery is quicker than a DRIL as a conduit vein does not have to be harvested for the surgical bypass.²⁰ This procedure has limited clinical experience, but is an alternative for surgeons who are reluctant to ligate the native artery.²⁰

Narrowing the arterial anastomosis of the dialysis access has also been described using a banding technique. The premise is that banding will increase the fistula resistance, which will indirectly increase perfusion to the extremity distal to the fistula.^{12,22-24} Unfortunately, the results have been inconsistent as it has been difficult to achieve a balance between increasing resistance in the dialysis access and accidental access thrombosis. If the band is too loose, there will be no change in symptoms. If the band is too tight, thrombosis of the dialysis access occurs. The dialysis access can also be narrowed by the MILLER technique, which uses a balloon to serve as a template for the Miller ligature to narrow the dialysis access.^{9,10} Recently, Zangan and Van Ha described using a constrained Wallstent[®] (Boston Scientific, Natick, MA) narrowed to 4 mm by a suture as a minimally invasive technique to increase resistance within the fistula⁹ for the treatment of dialysis access steal.

SUMMARY

In summary, significant dialysis access induced ischemia is rare, but a serious complication of dialysis fistula and graft creation. The DRIL procedure has been shown to be successful at reversing the symptoms of hand ischemia caused by upper extremity dialysis access grafts and fistulas. Studies have shown good results and patency rates that have helped to alleviate the initial concerns of bypass conduit patency and viability of the hand post-operatively. The bypass grafts need to be evaluated frequently to identify potential graft failures, which may require surgical or endovascular revision. Similar to all other aspects of dialysis access care, close communication between the nephrologists, surgeons, and interventional radiologists caring for dialysis patients with DRIL anatomy is crucial. Given the promising results of

the DRIL technique, interventional radiologists need to be fully aware of this procedure.

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