Supplement 3: Surgical Approaches to the Treatment of Steal

The optimal remedial treatment is dictated by several factors including the etiology of the hemodynamic change, which includes not only anatomic issues, ie stenosis of the inflow vessels or outflow vessels, but also hemodynamic/flow volumes of the access. The utility of the AV-access, the patient's comorbidities, the availability of adequate autogenous conduit, the patient's future vascular access options and patient preference. Since preventing further disability is of importance, the initial question for most patients with moderate to severe symptoms is whether the AV-access should be simply ligated versus attempts made to salvage the AV-access. AV-access ligation should theoretically reverse the hemodynamic changes associated with the AV-access although it may not reverse all of the steal-associated symptoms, particularly the neuropathy. AV-Access ligation may be the most appropriate treatment for patients with acute symptoms after the creation of an AVG and those with advance comorbidities. However, it is important to emphasize that rESKD and its therapy requires a lifelong plan and it is not be prudent to always just abandon a potential hemodialysis access option, particularly since a history of AV-access steal is a predictor of future episodes and it is not always feasible to simply re-site the AV-access on the contralateral extremity.

Patients requiring treatment for AV-access steal should likely undergo an arteriogram (i.e. CTA or catheter-based) to exclude any potential inflow lesion. If present, there are a variety of corrective endovascular and open surgical approaches, particularly for the common lesion at the origin of the subclavian artery. However, correcting the inflow lesion may be insufficient to reverse all of the hemodynamic changes contributing to the steal symptoms. This highlights the importance of noninvasive arterial imaging prior to AV-access creation, which may help exclude an arterial inflow lesion and should be mandatory in patients deemed high risk for AV-access steal. It may also help the surgeon plan and consider using the other extremity if that extremity has fewer or no lesions.

The optimal treatment for patients without a contributory inflow lesion remains unresolved and there are proponents of the various approaches. Ex vivo testing and hemodynamic modelling have demonstrated that they are all effective, but the DRIL - distal revascularization and interval ligation and the PAI - proximalization of the arterial inflow may provide the greatest hemodynamic benefit.[1,2] Leake et al. reported from their large series that the AV-access salvage rate was greatest with the DRIL while the complications were highest for the RUDI and flow liming approaches.[3] In a systematic review, Al Shakarchi et al.[4] found all strategies were successful in relieving symptoms but the DRIL was associated with the best AV-access patency.

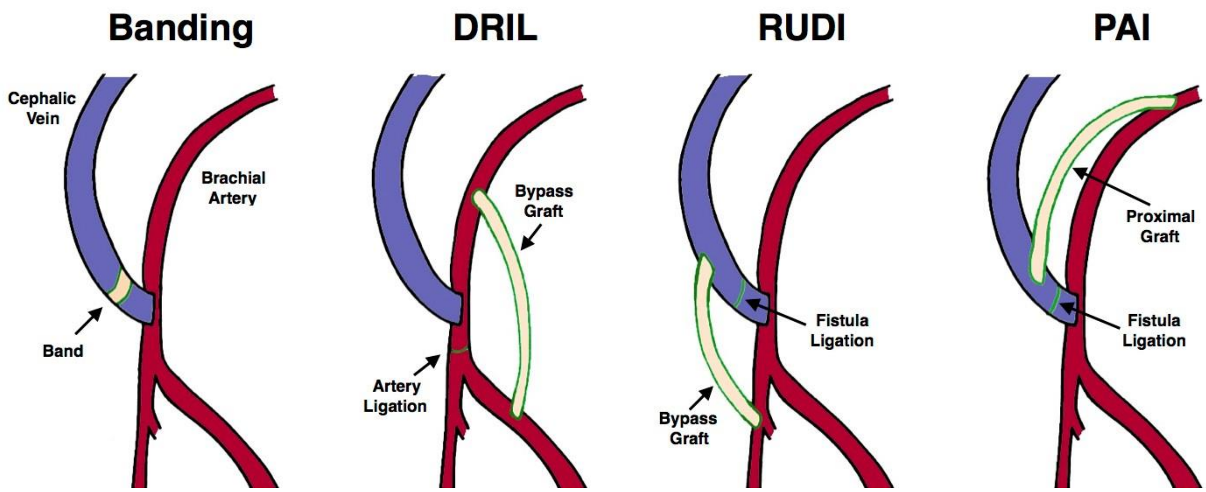
The goal of flow limiting strategies (e.g. narrowing of the anastomosis, diameter reduction of the outflow vein, ligation of draining veins) is to augment the distal perfusion pressure, reducing volume flows within the access while maintaining sufficient flow through the AV-access for effective dialysis.[5-8] This can be facilitated by intraoperative noninvasive monitoring of the digital perfusion.[6] Flow limiting approaches may have a role for patients with AV-access steal associated with "high flow" fistulas (i.e. > 1200 mL/min) but may not be effective for patients with extensive tissue loss or patients that have anatomic reasons for their steal.[9]

A variation of a flow limiting strategies is the PAI - proximalization of the arterial inflow procedure (**Figure 18.1**) which converts an AV-access based off the brachial artery at the antecubital fossa to one based off the more proximal brachial artery using a small caliber prosthetic conduit.[10,11] It may convert an autogenous access to a composite prosthetic/autogenous access in the case of an autogenous brachial-cephalic access although all autogenous alternatives have been described[12]. It may be an option for patients without sufficient autogenous conduit for a DRIL, but may not be effective for patients with significant tissue loss.[10]

The RUDI - revision using distal inflow (**Figure** 18.1) effectively converts an AV-access based off the brachial artery at the antecubital fossa to one based off a more distal inflow site, typically the proximal radial artery.[13] It has a role for steal symptoms related to "high flow" AVFs or for AVFs causing high output ongestive heart failure (independent of any symptoms related to hand ischemia).[13] Misskey et al.[14] compared their outcomes with the RUDI and DRIL and reported that the procedures were associated with comparable outcomes in terms of patency, symptom relief, and survival.

The DRIL (**Figure 18.1**) is essentially a brachial artery bypass with the proximal anastomosis sited proximal to the AVF anastomosis and the distal anastomosis sited distal to the AVF anastomosis. Concomitant with the bypass, the brachial artery immediately distal to the AVF anastomosis is ligated to prevent any retrograde flow. This approach has been reported to salvage the AV-access and reverse the related hand ischemia in over 80% of cases.[15,16] Illig et al.[17] measured intra-arterial pressures before and after the DRIL procedure and demonstrated that it effectively reverses the hemodynamic change.

Figure 18.1: Surgical treatment of Steal Syndrome



The following management strategies for steal syndrome are for a patient with a brachiocephalic AVF, as follows:

DRIL – a distal revascularization and interval ligation (DRIL) procedure. Note the autogenous or synthetic bypass graft and the ligature on the brachial artery immediately proximal to the distal anastomosis for brachial-brachial bypass

RUDI – Revision using distal inflow. Note that the brachial artery anastomosis to the brachial-cephalic access was ligated. A bypass graft is placed from the radial artery to the proximal aspect of original access

PAI – proximalization of the arterial inflow . Note that the autogenous access has been dissembled and a bypass graft is inserted between the more proximal brachial artery and the proximal segment of the original AVF

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