Dialysis Access Steal Syndrome: Prevention, Diagnosis and Treatment

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No Financial Disclosures
Incidence of Ischemia in Patients with Arteriovenous Access (4853 procedures) (Zanow, et al.)

<table>
<thead>
<tr>
<th>Location</th>
<th>Incidence</th>
<th># of Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snuffbox AVF</td>
<td>0.0%</td>
<td>59</td>
</tr>
<tr>
<td>Wrist AVF</td>
<td>0.3%</td>
<td>1999</td>
</tr>
<tr>
<td>Elbow AVF</td>
<td>1.8%</td>
<td>1870</td>
</tr>
<tr>
<td>--brach-cephalic</td>
<td>0.9%</td>
<td>1345</td>
</tr>
<tr>
<td>--brach-basilic</td>
<td>3.7%</td>
<td>274</td>
</tr>
<tr>
<td>--brach-ceph/bas</td>
<td>5.2%</td>
<td>251</td>
</tr>
<tr>
<td>PTFE grafts</td>
<td>2.2%</td>
<td>925</td>
</tr>
</tbody>
</table>
Onset Time of Ischemia in Patients with Arteriovenous Access (Zanow, et al.)

<table>
<thead>
<tr>
<th>Ischemic Onset Time</th>
<th>AV Fistula (126)</th>
<th>AV Graft (62)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute (&lt; 30 days)</td>
<td>29.4%</td>
<td>37.1%</td>
</tr>
<tr>
<td>Subacute (30 - 365 days)</td>
<td>23.8%</td>
<td>43.6%</td>
</tr>
<tr>
<td>Chronic (&gt; 1 year)</td>
<td>46.8%</td>
<td>19.3%</td>
</tr>
</tbody>
</table>
Strategies to Prevent Arterial Steal Following Hemodialysis Access

- Preoperative testing to identify proximal arterial lesions
- Minimize use of brachial artery inflow
  - Radiocephalic fistula if feasible
  - Proximal radial artery inflow
- Selective venous arterialization at elbow with ligation of deep perforating branch
- Primary axillary artery inflow in high risk patients
- ? Tapered grafts to limit flow
Figure 1. Aortic arch angiogram revealing a subtotally occluded, calcified, ostial left subclavian artery (*) causing poor perfusion to a left-sided AVF.
Proximal Radial Artery Fistula

- Alternative when wrist fistula not feasible

- Adequate arterial inflow but reduced risk of steal compared to brachial artery fistulas

- Excellent patency rates
Brachiocephalic AV fistula with ligation of deep perforating branch

- Clamping of perforating vein increased radial artery pressure significantly after brachiocephalic AV fistula
- Ligation of deep perforating branch recommended for improved fistula maturation and reduced incidence of steal following brachiocephalic AV fistula

Moini et al JVS 2008
Prevention of vascular access hand ischemia using the axillary artery as inflow

William Jennings, MD, Robert Brown, MD, John Blebea, MD, MBA, Kevin Taubman, MD, and Ryan Messiner, DO, *Tulsa, Okla*

**Final Access Venous Outflow Configuration**

Type I access outflow
- Axillary artery
- Cephalic vein outflow
- Transposed basilic vein
- Median cubital vein

Type II access outflow
- Axillary artery
- Transposed basilic vein
- Brachial vein outflow
- Forearm basilic vein

**Graph:**
- 100
- 90
- 80
- 70
- 60
- 50
- 40
- 30
- 20
- 10
- 0

| Months | Cumulative Patency
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
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<tr>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>15</td>
<td>70</td>
</tr>
<tr>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>

**Legend:**
- Dotted line: Cumulative Patency
- Dashed line: Assisted Patency
- Solid line: Primary Patency
Do tapered grafts reduce the incidence of arterial steal?

- **Maybe**: Hiranaka, T: Prospective, randomized trial of tapered and straight grafts for hemodialysis access
  - 60 grafts (2/20 straight 6mm., 0/40 tapered 4-6mm.)
- **No**: Schaffer, D: Prospective randomized trial of 6 mm v 4-7 mm PTFE grafts for hemodialysis access in diabetic patients
  - 59 patients – no difference ischemic complications but significant increase in thrombosis risk for tapered grafts
- **No**: Dammers, R: Evaluation of 4-7 mm. v 6 mm. brachial-antecubital grafts for hemodialysis
  - 109 grafts - no significant difference in graft flow rates or patency
Noninvasive Assessment of Ischemic Complications of AV Access

• Evaluation of ischemia / steal syndrome
  • digital PPG with fistula compression
  • volume flow measurements
  • flow reversal in distal artery
LT FOREARM DISTAL
Vol Flow 2463 cc/min
Area 0.263 cm²
Individualized Treatment of Dialysis Access Steal Syndrome
(not all steals are equal)

• If access flow rate higher than necessary (> 1 L/min)
  – Restrict flow
    • Banding (intraoperative flow monitoring)
    • Revision using distal inflow (RUDI)
• If flow adequate (< 1 L/min)
  – Distal revascularization interval ligation (DRIL)
  – Proximalization of arterial inflow (PAI)
• If ischemia severe
  – Ligate access
  – Search for new site
Techniques to Correct Access Related Ischemia

- Plication or banding
- Ligation distal vein or branches
- **Ligation distal artery (to eliminate flow reversal)**
- Distal revascularization interval ligation (DRIL)
- Proximalization of arterial inflow (PAI)
- Revision using distal inflow (RUDI)
- Minimally invasive limited ligation endoluminal-assisted revision (MILLER)
- Ligation of access
Steal Syndrome

Banding

Plication

Interposition

Banding
Minimally Invasive Limited Ligation Endoluminal-assisted Revision (MILLER) for treatment of dialysis access-associated steal syndrome

- Small (1-2 cm) skin incision
- 4-5 mm endoluminal balloon
- Standardizes desired reduction of inflow size
Effectiveness of surgical banding for high flow in brachial artery-based hemodialysis vascular access

Roel H. D. Vaes, MD, a Rosanne Wouda, MD, a Magda van Loon, PhD, b Frank van Hoek, MD, PhD, c Jan H. Tordoir, MD, PhD, b,d and Marc R. Scheltinga, MD, PhD, a,d Veldhoven, Maastricht, and Nijmegen, The Netherlands

- Banding of fistulas with > 2 L/min flow
- 50 patients – banding 30 +/- 6 mos after AVF
- Initial reduction in flow >50% (3070 vs 1490)
- Recurrent high flow (> 2 L) in 52% within 12 mos
- Risk factors for recurrent high flow
  - Young age ( < 45 yrs ) (p=.02)
  - Access flow ( > 1 L / min immediately after banding) (p=.03)
Distal Revascularization Interval Ligation

- Reliably restores antegrade flow to ischemic limb
- Eliminates potential physiologic pathway for steal mechanism
- Maintains continuous dialysis access in difficult patients
- Popular exam answer
Steal Syndrome - DRIL Procedure


- 61 patents underwent 64 DRIL procedures
- All autogenous access
- Timing of access to DRIL dictated by symptoms
  - <24 hrs (19%), 1-7 days (29%), 7-30 days (8%), >30 days (44%)
- 10 DRIL patency 71% at 5 years
- Relief of ischemic symptoms in 78%
Proximalization of the arterial inflow: A new technique to treat access-related ischemia

J Zanow, U Kruger, H Scholz

- Effective in treating access related ischemia
- Does not sacrifice natural arterial continuity
- Alternative to DRIL
PAI – proposed mechanism of action

• Increases volume flow in access **BUT**

• More proximal arterial anastomosis should increase flow to the forearm by increasing pressure at the split point between the distal circulation and the dialysis access

• Proximal arterial anastomosis also initiates collateral flow at higher point in the arm which is advantageous to prevent or treat ischemic symptoms in the hand
Revision Using Distal Inflow (RUDI)

- Ligation of fistula at origin with reestablishment of fistula inflow via bypass from more distal arterial source (proximal radial or ulnar artery)
- RUDI lengthens fistula and reduces diameter
  - **Pouiseuille’s law** - flow proportional to $r^4$ and inversely proportional to length of tube
- Preserves antegrade flow putting fistula at risk, not native arterial supply to hand

Minion et al, Ann Vasc Surg 2005
Revision Options for Treatment of Brachiocephalic Fistula Steal

- **A** DRIL procedure
- **B** RUDI procedure
- **C** PAI procedure
Ischemic Monomelic Neuropathy

- Uncommon and potentially devastating complication of brachial artery based AV access procedure.
- Diabetes and female gender predominate
- Acute, severe and often irreversible dysfunction of radial, median and ulnar nerves producing claw hand deformity
- Hand is often warm with palpable radial or ulnar pulse or audible Doppler signal
- Absence of severe tissue ischemia in affected extremity differentiates ischemic monomelic neuropathy from vascular steal.
Ischemic Monomelic Neuropathy

- Pathophysiology obscure – probably brief ischemic event with alteration in blood flow to vasa nervosum.

- Early diagnosis and intervention with access closure recommended in patients with available alternative access sites.

- Recovery is at best unpredictable and even with appropriate management strategies and early intervention, patients may be left with a significant clinical deficit.
A 68-year-old man develops pain in the left hand 6 weeks after creation of a left autogenous brachial-basilic upper arm transposed arteriovenous access for dialysis access. The patient presents with a cool hand; he has numbness while on dialysis. On physical examination of the left arm, the fistula has a palpable thrill with no edema, a palpable brachial artery pulse, non-palpable radial and ulnar artery pulses, and a cool hand with gangrenous ulcers at the tips of his second and third digits. He has decreased sensation, but normal motor function. An arteriogram is obtained (image is show below). Which of the following is the best treatment plan for this patient?

- 68 year old man with coolness, numbness six weeks after BVT
- Gangrenous ulcers tips 2,3 digits
- absent distal pulses

Select one:

- a. a distal revascularization with interval ligation procedure
- b. banding of the AV access outflow
- c. observation with a nitropaste patch to the hand
- d. emergent ligation of the brachial artery
- e. emergent ligation of the AV access

No PPG
No flow measurements
No distal imaging
Consider other options
- RUDI
- PAI
Should a DRIL procedure be the first procedure for management of steal syndrome?

Reasonable option but not in my opinion
Thank you

- Digital / Brachial Index < 0.6 predicts patients at risk for severe steal
- All patients with severe steal had DBI < 0.6
  - Average 0.44 (Range 0.24 – 0.58)
- Sensitivity 100% Specificity 59%
- Pos Predict Value 18% Neg Predict Value 100%
- No access revision at initial operation if DBI < 0.6
- If revising access to steal, must raise DBI to > 0.6
Do preoperative finger pressures predict early arterial steal in hemodialysis access patients? A prospective analysis.

- Valentine, et al., JVS 36:351,2002
- 72 brachial artery based access procedures studied prospectively - 12 AVF, 60 PTFE (10 taper)
- 9 (64%) of patients with steal had DBI < 1.0
- 18 (31%) of patients without steal had DBI < 1.0
- Preop FP lower (131 vs 151) (p<0.3) in patients with steal
- No absolute FP or DBI below which steal was inevitable
Relationship of hemodialysis access to finger gangrene in patients with ESRD

- Yeager, et al, JVS 2002
- 23 patients with finger gangrene with ipsilateral AVF
- Young diabetic patients with diffuse atherosclerosis
- Bilateral gangrene in 61% of patients
- Finger gangrene result of distal atherosclerosis and not primarily related to dialysis access
Midterm outcome after the distal revascularization and interval ligation (DRIL) procedure

Thomas S. Huber, MD, PhD, Michael P. Brown, DO, James M. Seeger, MD, and W. Anthony Lee, MD, Gainesville, Fla

Conclusion: The DRIL procedure safely and effectively relieves the symptoms of severe access-related hand ischemia while preserving the access. The midterm results suggest that the DRIL bypasses are durable, although long-term graft surveillance may be justified given the observed failures. (J Vasc Surg 2008;48:926-33.)
<table>
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<th>Distal brachial artery pressure (mmHg)</th>
<th>Access flow ($Q_F$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native circulation</td>
<td>155</td>
<td>180/65 (110)</td>
<td>0</td>
</tr>
<tr>
<td>Brachial-axillary access</td>
<td>29</td>
<td>75/27 (43)</td>
<td>530</td>
</tr>
<tr>
<td>Loop axillary-axillary access</td>
<td>110</td>
<td>154/62 (101)</td>
<td>1536</td>
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Analysis of Options for Mitigating Hemodialysis Access-Related Ischemic Steal Phenomena
Gradman, Ann Vasc Surg, 2004

- Analyzed theoretical effect of six access modifications on forearm blood flow
- Flow model predicts greatest increase in distal flow with
  - DRIL
  - 6 mm axillobrachial bypass without interval ligation
  - Conversion to axillary-axillary loop access
<table>
<thead>
<tr>
<th>Axillo-brachial Bypass</th>
<th>DRIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axillary Origin</td>
<td>Mid-Brachial DRIL</td>
</tr>
<tr>
<td>Axillary Loop</td>
<td>Extended Axillo-brachial Bypass</td>
</tr>
</tbody>
</table>
PAI vs DRIL (Gradman, et al)

- Extended axillobrachial bypass (distal revascularization half of DRIL) increases forearm flow by factor of 1.2 – 12.1 but may also increase retrograde flow to access.
- Ligation intervening vessel (conversion to DRIL) increases forearm flow by additional factor of only 1.4 – 1.9.
- Axillary-axillary loop approaches DRIL in improving forearm flow.
PAI vs DRIL

- DRIL effective intervention for steal syndrome - ? gold standard

- Understandable reluctance to ligate normal artery making alternative treatments attractive

- Axillary based access or extended brachial bypass clinically effective in relieving steal
### Table II. Data from temporary occlusion of vessels to simulate selected configurations

<table>
<thead>
<tr>
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<th>Distal brachial artery flow ($Q_C$)</th>
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<th>Access flow ($Q_F$)</th>
<th>Distal brachial artery flow tracing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native circulation</td>
<td>33</td>
<td>114/52 (75)</td>
<td>0</td>
<td><img src="image" alt="Native circulation" /></td>
</tr>
<tr>
<td>Brachial-axillary access</td>
<td>13</td>
<td>59/31 (40)</td>
<td>450</td>
<td><img src="image" alt="Brachial-axillary access" /></td>
</tr>
<tr>
<td>Extended bypass</td>
<td>28</td>
<td>80/37 (52)</td>
<td>630</td>
<td><img src="image" alt="Extended bypass" /></td>
</tr>
<tr>
<td>DRIL</td>
<td>36</td>
<td>92/44 (60)</td>
<td>490</td>
<td><img src="image" alt="Distal revascularization-interval ligation" /></td>
</tr>
</tbody>
</table>
Algorithm for prevention and treatment of steal (Gradman, et al)

- If small artery encountered at initial surgery to place AV graft axillary loop constructed
- If severe steal immediately after constructing brachial axillary graft replaced with axillary loop
- If late symptoms convert to axillary loop or perform extended axillobrachial bypass
- If bypass alone insufficient consider ligation of intervening artery (DRIL) but rarely (? never) necessary
Precise banding of an AVF using a coronary dilator as a dowel for reliable sizing of the restriction site. The restriction is created adjacent to the AVF anastomosis using polypropylene suture and sized in one-half millimeter increments, measuring AVF flow, until the target access flow is achieved (500-800ml/min).
Analysis of Options for Mitigating Hemodialysis Access-Related Ischemic Steal Phenomena
Gradman, Ann Vasc Surg, 2004

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- Ligation intervening vessel (conversion to DRIL) increases forearm flow by additional factor of only 1.4 – 1.9.
- Axillary-axillary loop approaches DRIL in improving forearm flow.
Conversion of straight brachio-axillary graft to tapered loop axillary-axillary access

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<td>1536</td>
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</table>
IMN – Malpractice Lawsuit

- Brachiocephalic AV fistula dominant arm – calcified forearm arteries, AICD nondominant arm
- c/o numbness in fingers 3 weeks later – no motor deficit – PPG normal - ? mild ischemic neuropathy
- Poor maturation fistula – ligated 3 mos later after increasing arm swelling secondary to Perm cath
- Residual numbness and difficulty using hand
- Trial emphasized failure to follow guidelines – evidence based, written by experts, sanctioned by SVS, NKF
- Plaintiff verdict $1.7 million (patient disabled for 15 years s/p BKA)
Diagnosis of monomelic ischemic neuropathy is a clinical diagnosis and immediate closure of the AV fistula is mandatory.

IMN is an indication for deconstruction or revision of the AV access.
Comments

• Flawed system of justice – complex medical issues decided by “jury of peers”
• Fraudulent expert testimony – if reviewed by vascular surgeons hard to imagine they would find fault with care
• Damage awards excessive
• Misuse of guidelines to prove negligence
“Law is supposed to provide deliberate judgments of right and wrong, so people know where they stand. America’s legal system today is more like a free-for-all.”

“Sensible judgments will be possible only when doctors, hospitals and other providers feel that justice will reliably distinguish between right and wrong and make predictable judgments about fair compensation. A trusted system of justice is the key.”

Philip K. Howard, Chair, Common Good, a legal reform coalition
Informed Consent

• Inform in great detail regarding every possible risk of procedure?

• Document discussion or risks with informed consent note in chart
Montefiore

CONSENT FORM
(to be signed by patient wherever applicable)

Date ___________________________ Time ___________________________ A.M. / P.M.

I. PERMISSION FOR OPERATIVE AND/OR DIAGNOSTIC PROCEDURE AND/OR TREATMENT
1. I hereby authorize Dr./Ms./Mr., or associates or assistants of his/her choice at Montefiore Medical Center to perform upon me/the patient named above the following operation(s) and/or procedure(s).

II. INFORMED CONSENT DISCUSSION: I hereby certify that I have explained the nature, purpose, benefits, risks of, and reasonable alternatives to the proposed procedure(s)/operation(s), and sedation and/or blood/blood products, when applicable. I have discussed potential problems related to recuperation, the likelihood of achieving treatment goals and the risks, benefits and side effects of reasonable alternatives, including the possible consequences of receiving no treatment. I have offered to answer any questions and fully answered such questions. I believe that the patient/relative/guardian fully understands what I have explained and answered.

Remarks: ____________________________________________________________

__________________________________________________________  ____________________________________________________________  ____________________________________________________________
Provider
SIGNATURE/CREDS  PRINT NAME  DATE/TIME

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Remarks: ____________________________________________________________

__________________________________________________________  ____________________________________________________________  ____________________________________________________________
Provider
SIGNATURE/CREDS  PRINT NAME  DATE/TIME
ACKNOWLEDGEMENT OF POTENTIAL RISK FACTORS OF FISTULA / GRAFT SURGERY IN THE UPPER EXTREMITY

Please read the information below in regards to the Risk Factors of Fistula / Graft Surgery.

Patients may experience the following problems:

- Numbness and/or coolness in forearm, and/or hand, and/or fingers (this is usually mild and may resolve by itself)
- Pain and/or burning sensation
- Loss of use of hand either temporary or permanent (although very rare)
- Multiple surgeries of fistula/graft to increase blood flow to hand
- Loss of dialysis access and need for further evaluation eg: ultrasound, and /or need for dialysis catheter
- Bleeding, infection, and/or injury to adjacent structures
- If patient has a slight or unnoticed carpal syndrome, this surgery may exacerbate the problem resulting in the possibility of Carpal Tunnel surgery.
- If patient has any neuropathy, this surgery may exacerbate the problem.

I understand that if I experience any of the above problems that I will notify my surgeon immediately.

By signing below, I agree that I have reviewed and understand the information above and that I have received a copy of the Potential Risk Factors of Fistula / Graft Surgery.
Measurement of flow volume

Volume = Cross-sectional area \cdot \text{Mean velocity} \cdot 60 
(mL/min) \quad (cm^2) \quad (cm/sec)

Cross-sectional area (cm^2): \pi d^2 / 4 
d: diameter
PHOTOLETHYSMOGRAPHY

PRE

POST

PPG
RIGHT Index Finger
Gain:.50  Speed:25  Amplitude:05mm

PPG
RIGHT Index Finger
Gain:.50  Speed:25  Amplitude:20mm
Ischemic Monomelic Neuropathy

Conclusions

• Must consider medicolegal consequences of decisions made in treating these potentially devastating complications

• If and until more effective strategies can be developed to prevent or manage IMN it is reasonable to recommend early diagnosis and intervention with access closure in patients with available alternative access sites

• Despite these recommendations recovery is at best unpredictable and even with appropriate management strategies and early intervention, patients may be left with a significant clinical deficit
Innovative Surgical Approaches to Maximize Arteriovenous Fistula Creation
Shenoy, Seminars in Vascular Surgery 2007

<table>
<thead>
<tr>
<th>Table 1 Objective Criteria for Fistula Maturation</th>
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<tbody>
<tr>
<td>Fistula flow</td>
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<tr>
<td>Needle stick segment (conduit)</td>
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</tbody>
</table>
Proximalization of Arterial Inflow: Loh, et al, SCVS 2015

• 38 PAI (2008 – 2014)
• 29% prior intervention for ischemic steal syndrome
• Radiocephalic avf (9), brachiocephalic avf (26), brachiobasilic avf (3)
• 34 / 38 targets to proximal brachial artery
• 1 year primary assisted patency 71%, secondary 74%
• Symptom resolution complete (69%), improved (22%)
• Average flow in 4 ligated avf + 629 cc/min
• Remaining fistulas average flow – 101 cc/min
• Concern that PAI can increase flow worsening steal
<table>
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<tr>
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<th>Vascular Steal Syndrome</th>
<th>Ischemic Monomelic Neuropathy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Onset</strong></td>
<td>Insidious</td>
<td>Immediate</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>+ +</td>
<td>+++++</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td>Variable</td>
<td>Female &gt; Male</td>
</tr>
<tr>
<td><strong>Access Location</strong></td>
<td>Wrist, forearm, upper arm</td>
<td>Forearm, brachial artery based</td>
</tr>
<tr>
<td><strong>Affected Tissue</strong></td>
<td>Skin &gt; muscle &gt; nerve</td>
<td>Nerve (multiple)</td>
</tr>
<tr>
<td><strong>Clinical Ischemia</strong></td>
<td>Severe</td>
<td>Mild</td>
</tr>
<tr>
<td><strong>Radial Pulse</strong></td>
<td>Absent</td>
<td>+/-</td>
</tr>
<tr>
<td><strong>Digital Pressure</strong></td>
<td>Markedly decreased</td>
<td>Normal or slightly decreased</td>
</tr>
<tr>
<td><strong>Reversibility</strong></td>
<td>Variable</td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Treatment Options</strong></td>
<td>Access revision (DRIL, banding)* / Ligation</td>
<td>? Access closure</td>
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Arterial steal can lead to ischemia in the distal extremity after placement of a dialysis graft or fistula. Decreased resistance in the access outflow tract creates a reversal of blood flow towards the access and away from the hand. Physiologic steal occurs in up to 90% of all AV accesses, but it is clinically symptomatic in less than 10%. Steal is more common in upper arm grafts and less in distal autogenous fistulas. Clinical symptoms range from mild ischemia, presenting as coolness and paresthesias on dialysis, to severe ischemia, presenting as rest pain, numbness, paralysis, finger contractures, and gangrene. Patients with clinically symptomatic arterial steal should be evaluated with an arteriogram to identify any proximal arterial stenosis. Treatment of the proximal artery alone with either endovascular or open surgical techniques may resolve symptoms.

In patients without proximal arterial stenosis or who do not resolve their symptoms with treatment of the inflow stenosis, further treatment options exist. Ligation of the access will resolve the symptoms, but it leaves the patient without an access for dialysis. Banding of the access outflow tract increases the resistance in the fistula. However, it may be difficult to judge the degree of stenosis required to alleviate the steal without causing thrombosis of the access. Distal revascularization with interval ligation (DRIL) involves ligation of the arterial outflow tract just distal to the arterial anastomosis, followed by a bypass from the artery proximal to the anastomosis to the artery distal to the area of ligation. The DRIL procedure is effective in treating ischemic pain and tissue loss, but may be less effective for neurologic deficits that have already occurred.

References:


**Incidence of Ischemia in Patients with Arteriovenous Access (Zanow, et al.)**

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</tr>
<tr>
<td>--brach-basilic</td>
<td>3.7%</td>
<td>274</td>
</tr>
<tr>
<td>--brach-ceph/bas</td>
<td>5.2%</td>
<td>251</td>
</tr>
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