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Steal Syndrome: The Role of the Vascular Lab

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Eighth Overlook
Noninvasive Vascular
Lab Symposium

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Steal Syndrome
Role of the Vascular Laboratory

- Prevent Steal – preoperative assessment
  - Arterial duplex
  - PVR, PPG
- Diagnose Steal – postoperative assessment
  - Digital PPG with fistula compression
  - Volume flow measurements
  - Flow reversal in distal artery
- Treat Steal – intraoperative assessment
  - Volume flow measurements
  - Digital PPG

Incidence of Ischemia in Patients with Arteriovenous Access (4853 procedures) (Zanow, et al.)

Location	Incidence	# of Procedures
Snuffbox AVF	0.0%	59
Wrist AVF	0.3%	1999
Elbow AVF	1.8%	1870
--brach-cephalic	0.9%	1345
--brach-basilic	3.7%	274
--brach-ceph/bas	5.2%	251
PTFE grafts	2.2%	925

Onset Time of Ischemia in Patients with Arteriovenous Access (Zanow, et al.)

Ischemic Onset Time	AV Fistula (126)	AV Graft (62)
Acute (< 30 days)	29.4%	37.1%
Subacute (30 - 365 days)	23.8%	43.6%
Chronic (> 1 year)	46.8%	19.3%

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

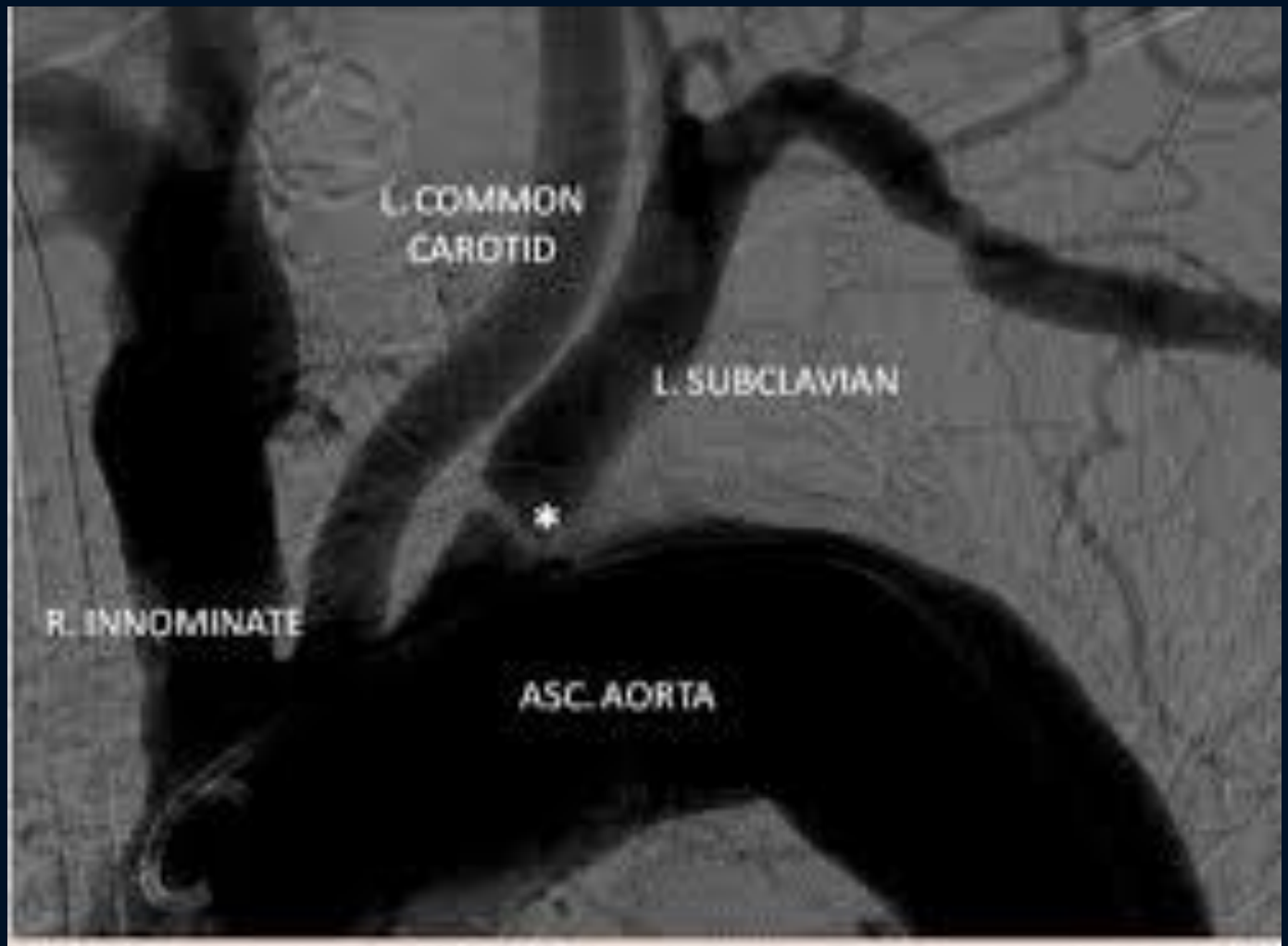
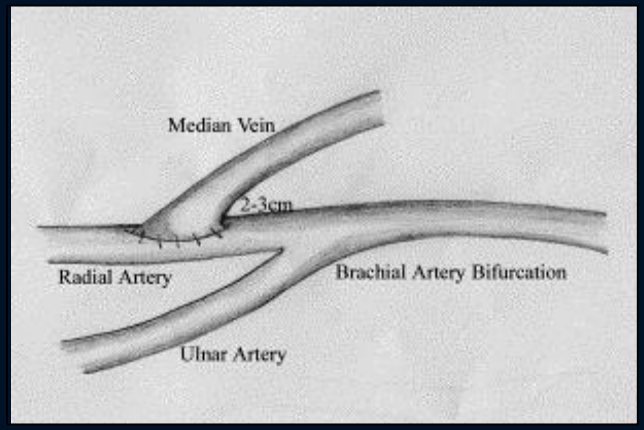


Figure 1. Aortic arch angiogram revealing a subtotally occluded, calcified, ostial left subclavian artery (*) causing poor perfusion to a left-sided AVF.

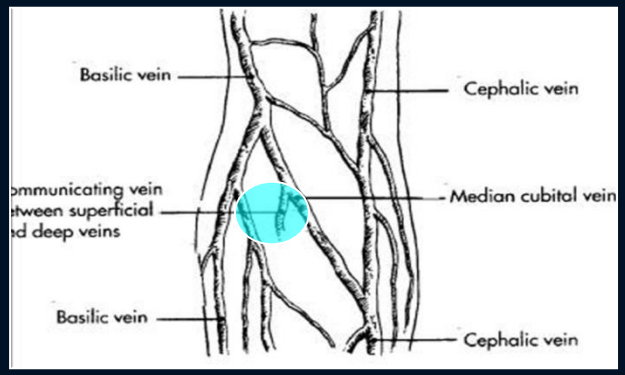
Proximal Radial Artery Fistula

- Alternative when wrist fistula not feasible
- Adequate arterial inflow but reduced risk of steal compared to brachial artery fistulas
- Venous anatomy critical – deep perforating branch of median antebrachial vein can be used for anastomosis or must be ligated
- 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

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

Location	Incidence	# of Procedures
Elbow AVF	1.8%	1870
--brach-cephalic	0.9%	1345
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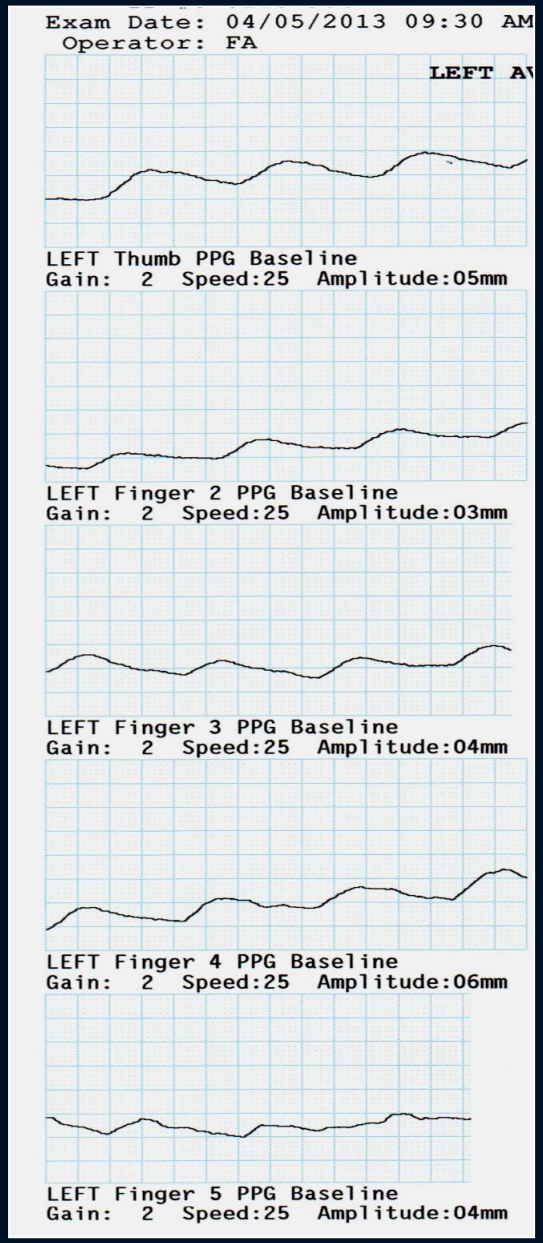
--brach-ceph/bas	5.2%	251

Relationship of hemodialysis access to finger gangrene in patients with ESRD

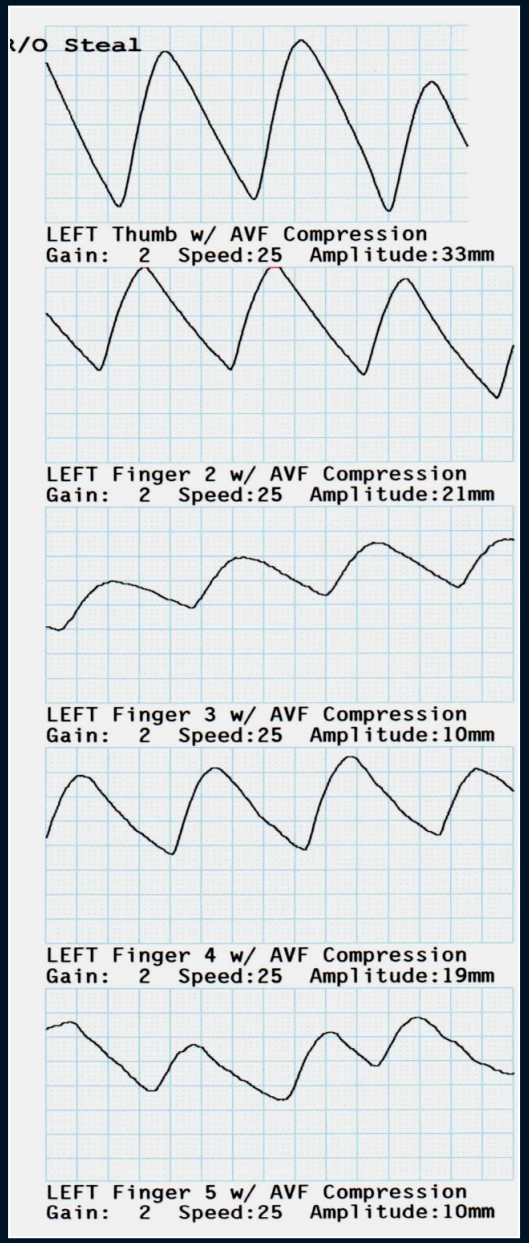
- Yeager, et al, JVS 2002
- 23 patients with finger gangrene with ipsilateral AVF
- Young diabetic patients with diffuse atherosclerosis
- Bilateral gangrene in 61% of patients
- Finger gangrene result of distal atherosclerosis and not primarily related to dialysis access

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



Baseline



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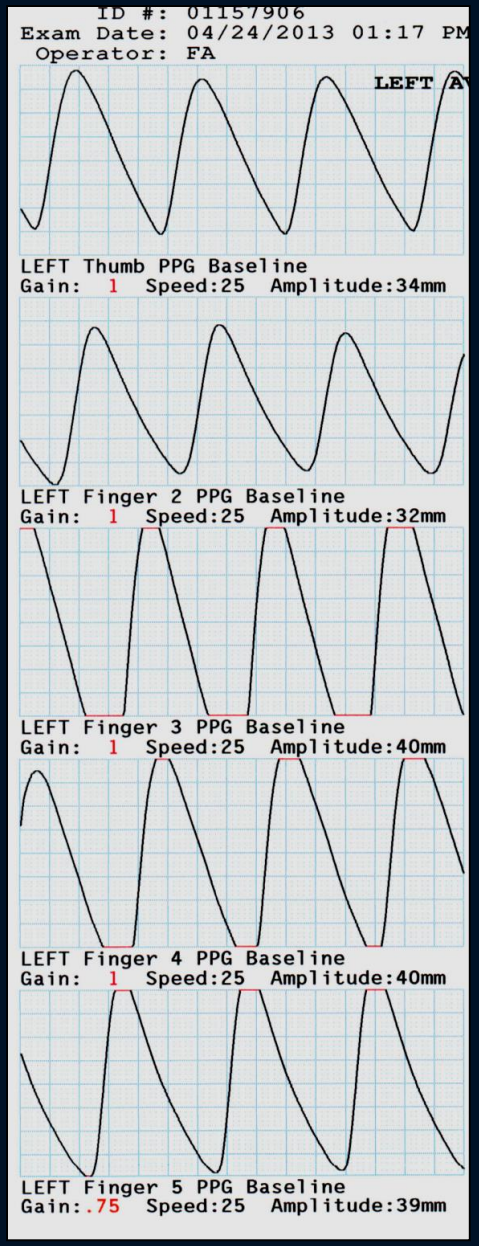
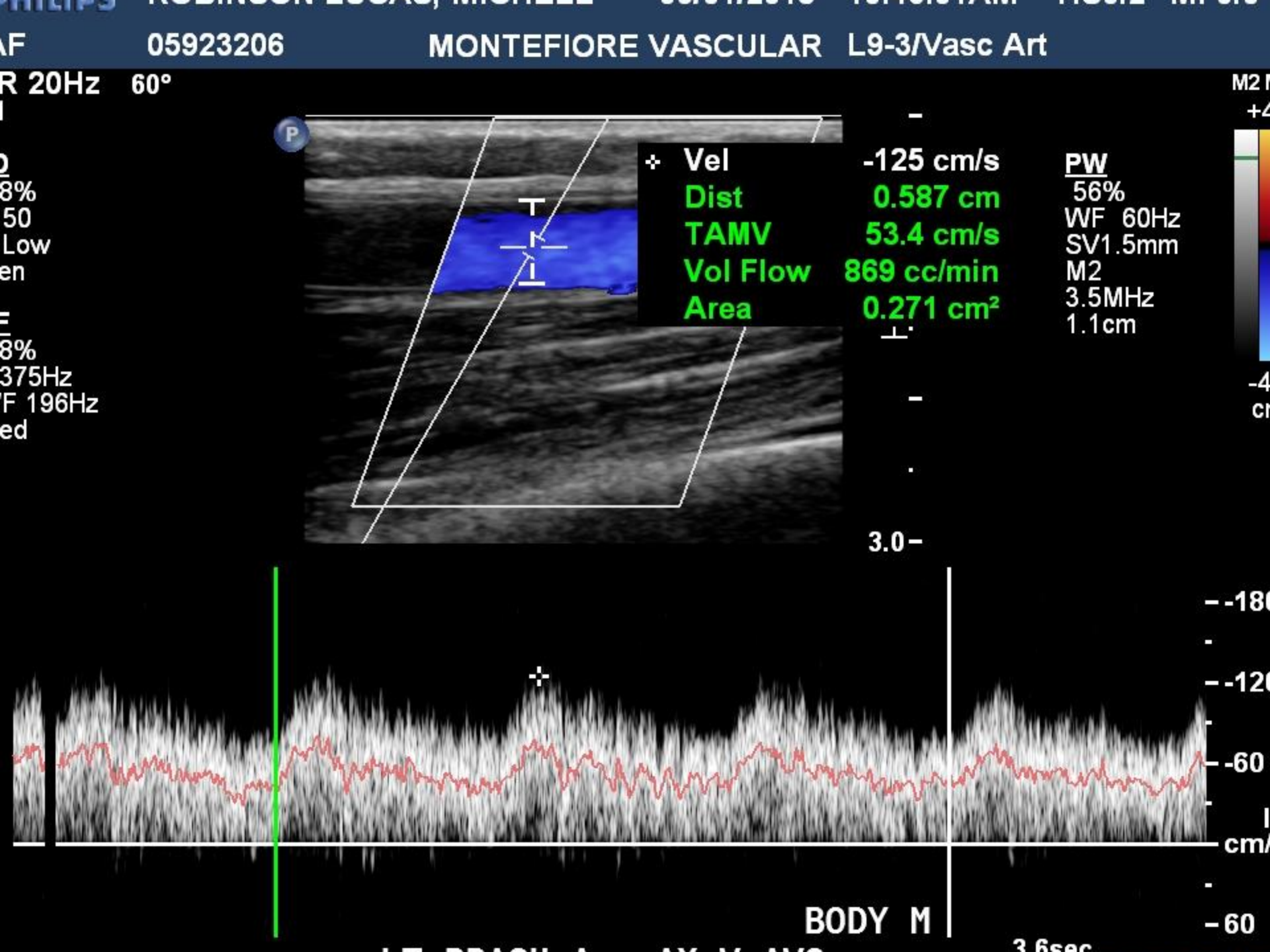


Proximalization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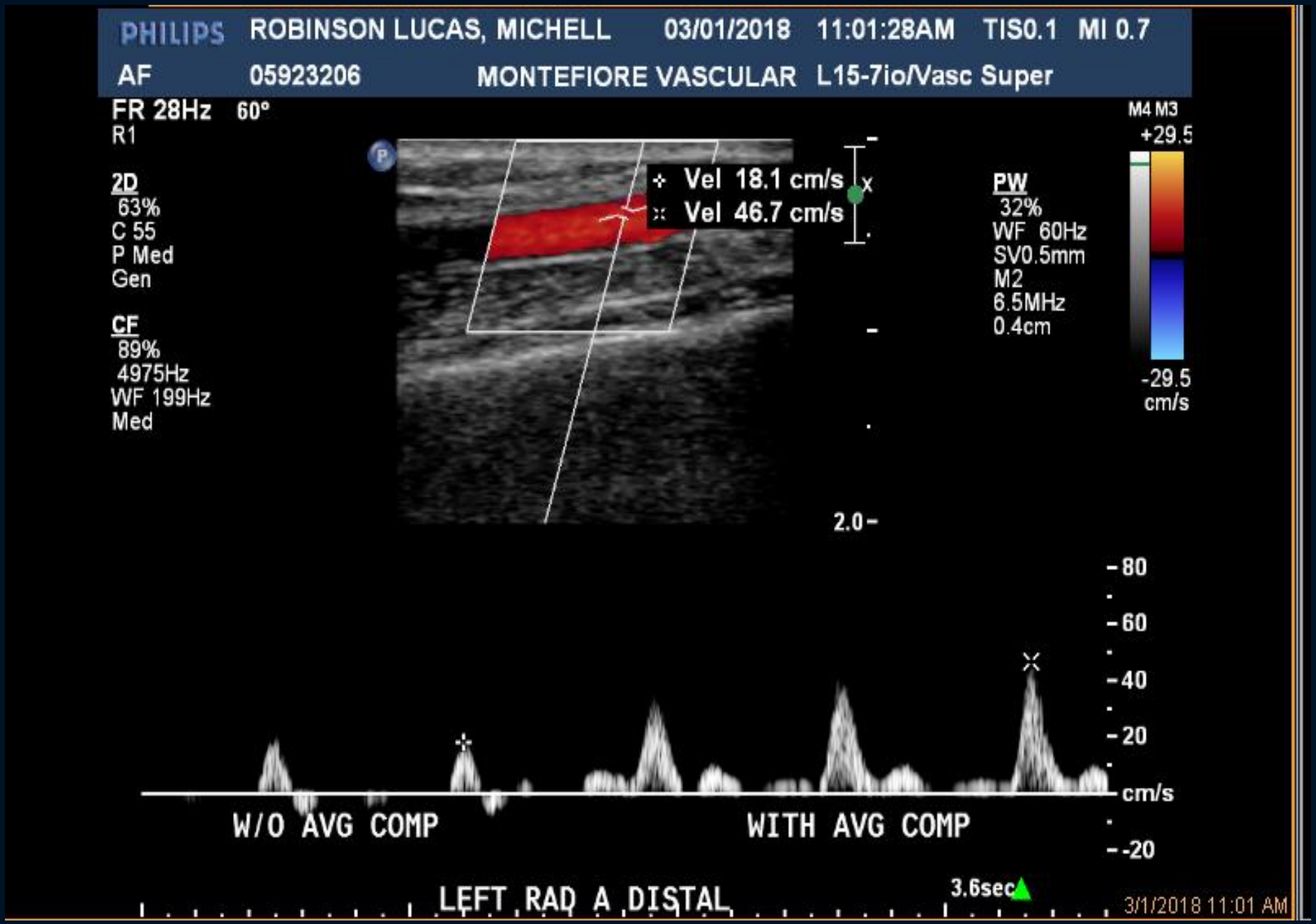
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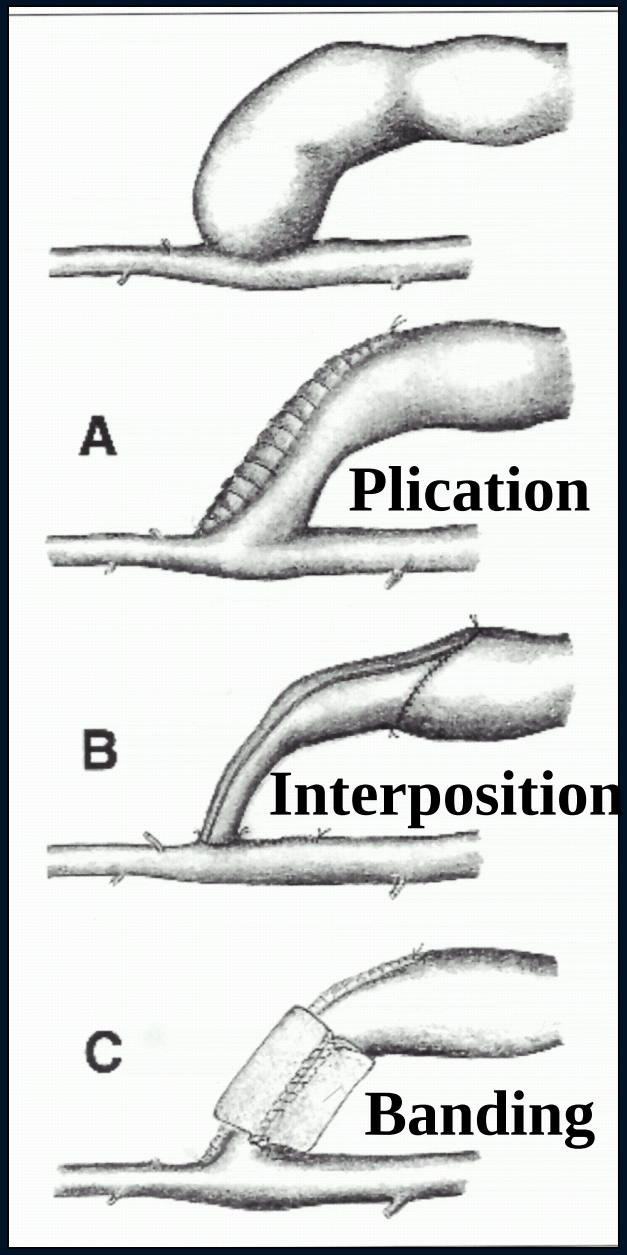
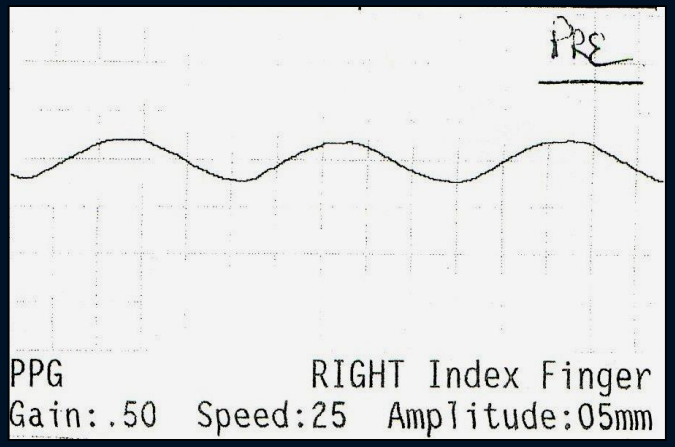
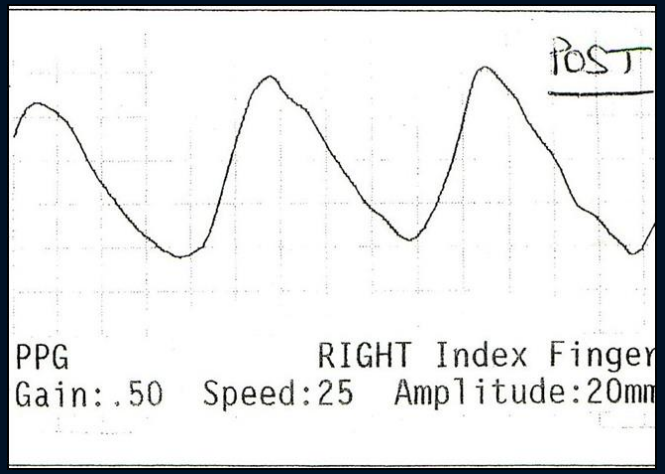
Individualized Treatment of Dialysis Access Steal Syndrome
(not all steals are equal)

- 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

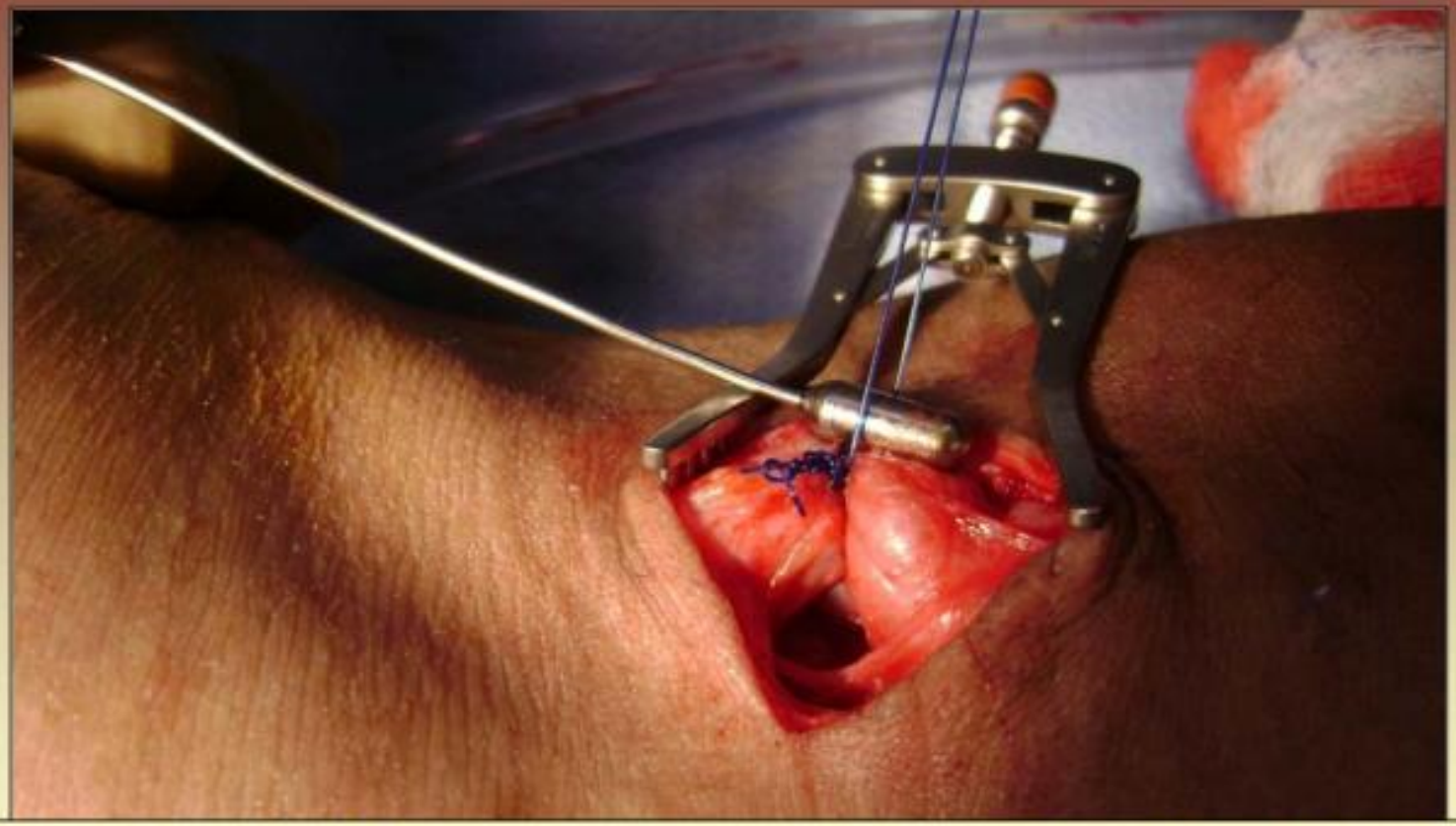
Steal Syndrome
Banding







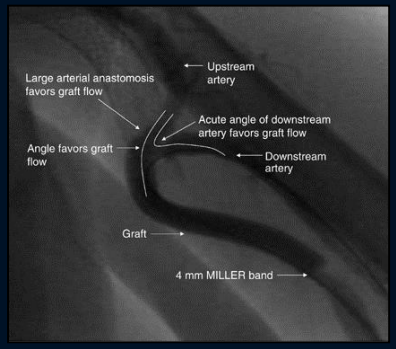
Precision Banding



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).

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

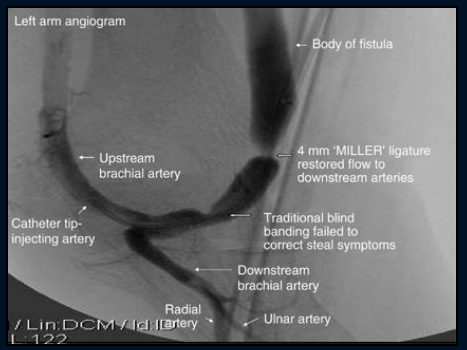
- Small (1-2 cm) skin incision
- 4-5 mm endoluminal balloon
- Standardizes desired reduction of inflow size



Fistulogram

Exposure

Limited Ligation



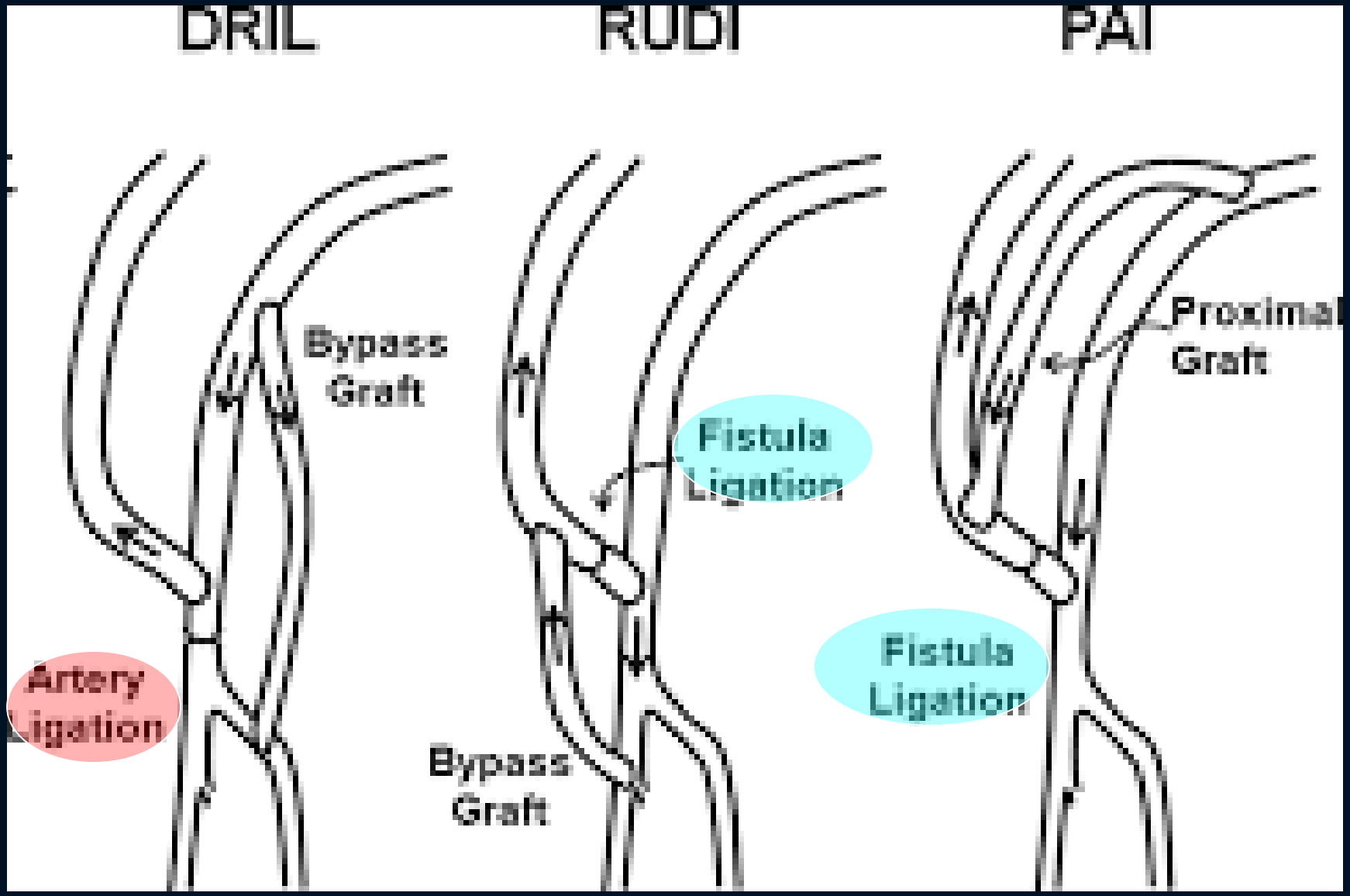
Completion

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
- 56% BC fistula, 40% BVT, 4% RC fistula
- 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)

J Vasc Surg, 2015

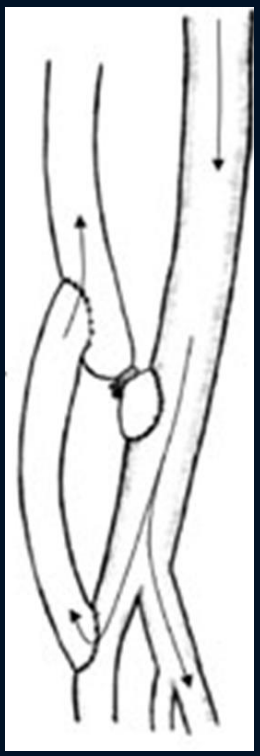

DRIL
RUDI
PAI
Bypass Graft
Artery Ligation
Fistula Ligation
Bypass Graft
Proximal Graft
Fistula Ligation

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
- Excellent clinical outcomes
- Popular exam answer

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



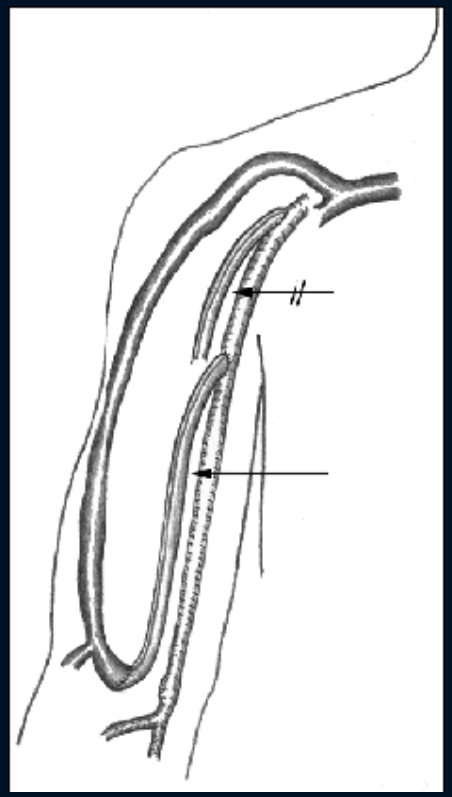
Minion et al, Ann Vasc Surg 2005

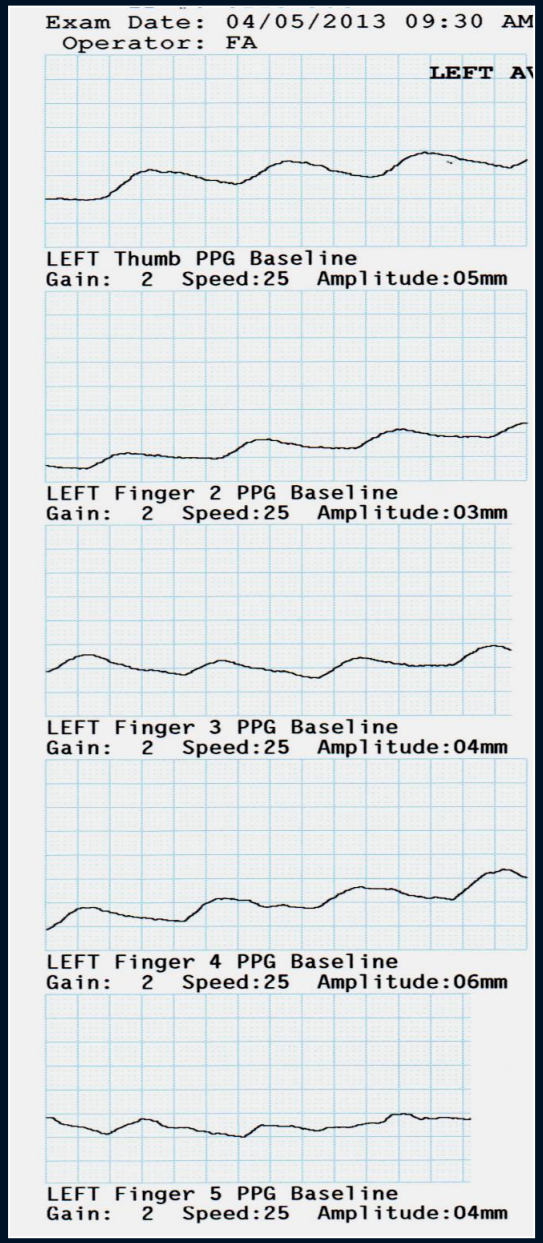
Proximalization of the arterial inflow: A new technique to treat access-related ischemia

J Zanow, U Kruger, H Scholz

J Vasc Surg, 43:1216-1221, 2006

- Effective in treating access related ischemia
- Does not sacrifice natural arterial continuity
- Alternative to DRIL





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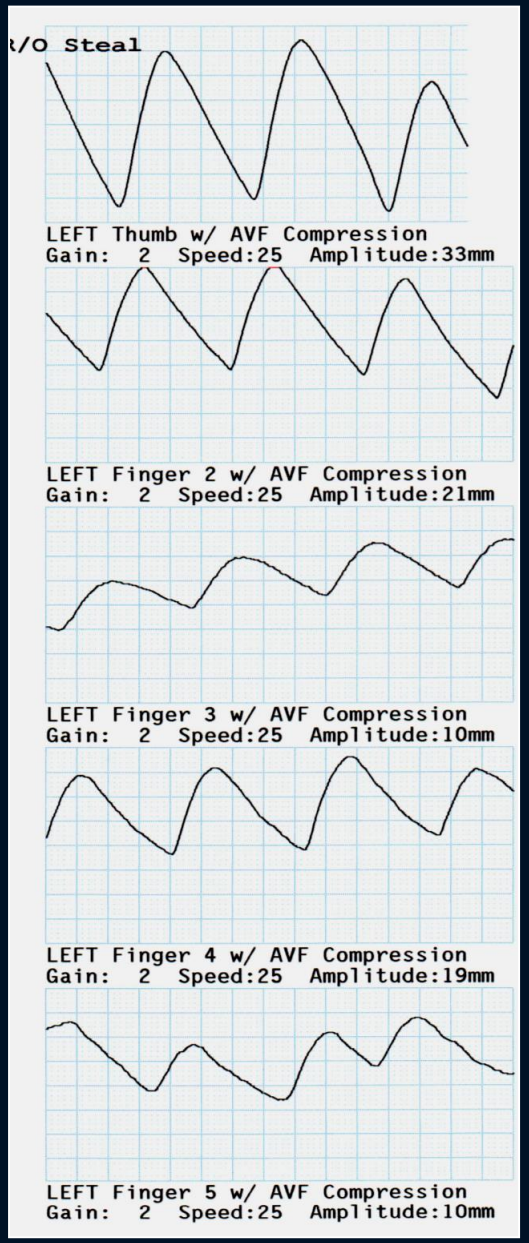

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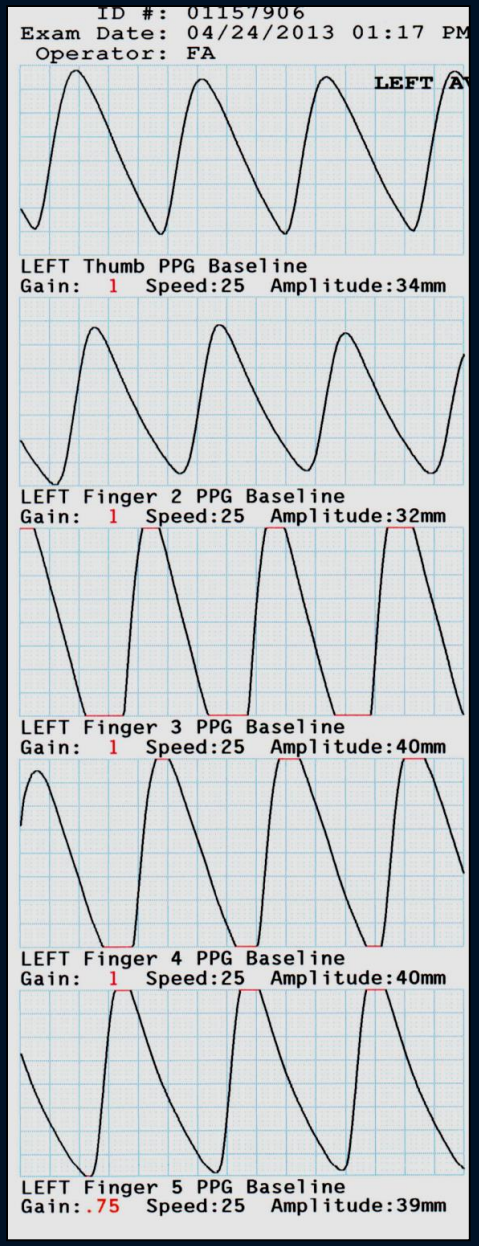


Proximalization

PAI – proposed mechanism of action

- 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

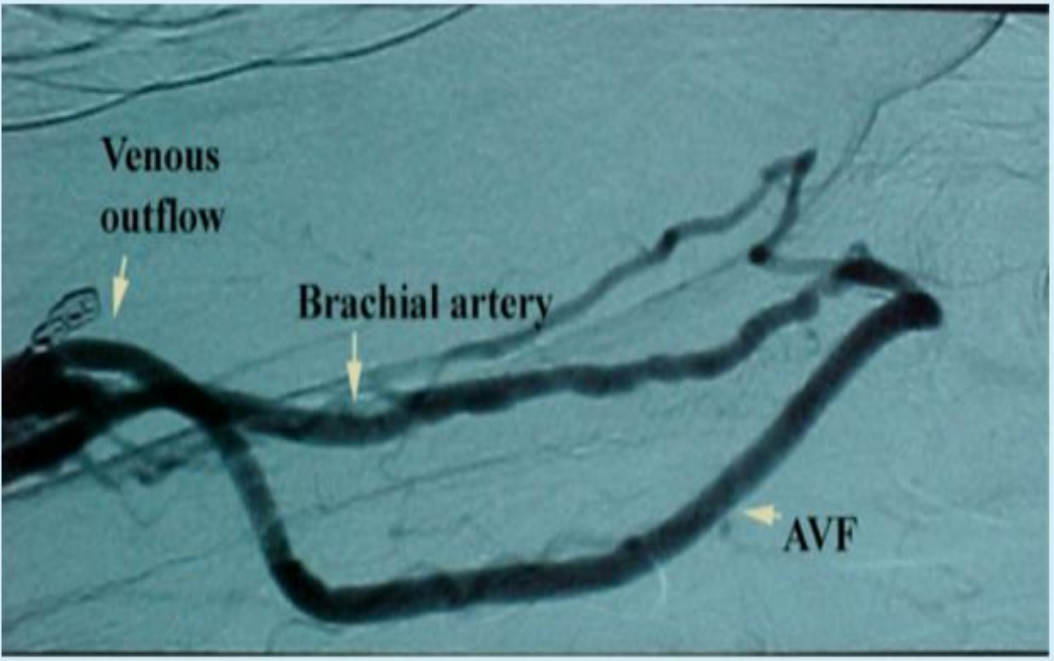
PAI vs DRIL

- 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

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

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?



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

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

No PPG
No flow measurements
No distal imaging
Consider other options
- RUDI
- PAI

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:

Knox RC, Berman SS, Hughes JD, Gentile AT, Mills JL. Distal revascularization-interval ligation: A durable and effective treatment for ischemic steal syndrome after hemodialysis access. J Vasc Surg 2003; 36 (2):250-6.

Aimaq R, Katz SG. Using distal revascularization with interval ligation as the primary treatment of hand ischemia after dialysis access creation. J Vasc Surg 2013;57:1073-8.

Thank you