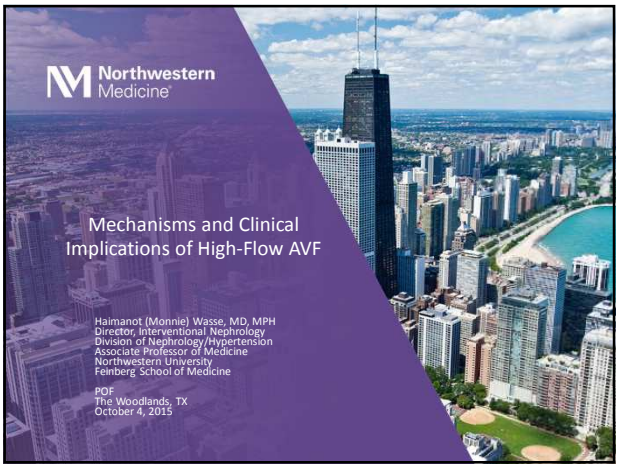


The ideal AVF

Just enough flow to avoid thrombosis while providing efficient, reliable dialysis

AVF blood flow: How much is too much?

- Necessary blood flow rate (BFR) for efficient dialysis ~400-600 ml/min
- High flow access is not well-defined, but believed to be > 2L/min, above which risk of high-output failure increases
- No absolute treatment criteria for a high-flow access
  - decision to initiate invasive management is unclear

Basile C, et al, NDT, 2008

What determines AVF blood flow?

- AVF blood flow volume is related to:
  - Location
  - Diameter of the anastomosis
  - Inflow artery dilation
  - Systemic blood pressure

What determines AVF blood flow?

- Flow rates: RC < BC, BB AVF's
- Regulation of Flow
  - Small AV conduits
    - AVF diameter < ¾ of inflow artery, flow regulated by 4th power of the AVF radius[1]
  - Large AV conduits
    - If diameter of anastomosis and outflow circuit ≥ of the inflow artery, flow regulated by resistances of peripheral vascular bed, inflow artery, collateral circulation [2]

[1] Malik J et al, Kidney Blood Press Res, 2009, [2] Wixon, CL J Am Coll Surg 2000

Access surgeon consensus on optimal AVF anastomotic size?

- No consensus
- Informal survey of vascular surgery colleagues at Methodist, Duke, Wash U, etc. re: optimal anastomotic size
  - 5-6 mm
  - 11 mm
  - 3 mm
  - 6 mm

AVF Anastomotic size determines flow

Clinically-validated computational fluid dynamic generated blood flows through AV communication of 1mm length (similar to AV anastomosis)

Mean BP	50 (mmHg)	70 (mmHg)	90 (mmHg)	100 (mmHg)
Anastomotic Diameter	Blood flow (ml/min)			
1 mm	117	149	179	191
2 mm	626	814	978	1060
3 mm	1605	2113	2394	2534

S.Shenoy©

Clinical Implications of High-Flow AVF

- Dialysis access-associated ischemic steal syndrome (DASS)
- Central venous stenosis/Venous hypertension
- High-output heart failure

Dialysis access-associated steal syndrome

DASS most common in:

- Diabetic patients with peripheral neuropathy
- Those with significant atherosclerotic peripheral vascular disease
- Patients often have history access ligation due to hand ischemia

Beathard G et al, Sem in Dial, Vol 26 (3) , 2013; Miller GA et al, KI Vol 77, 2009

Procedures to treat established DASS

- Steal syndrome can occur in high and low-flow settings
  - 20% of brachial-artery access procedures develop steal [1]
- Established surgical treatment for low-flow access with DASS [2]
  - Increase total circuit blood flow
    - Distal revascularization and interval ligation
    - Proximalization of arterial inflow
- **Treatment for high-flow access**
  - Add resistance to system and decrease total circuit blood flow
    - Banding

[1] Sidawy AN et al, J Vasc Surg, 2002; [2] Scali et al, Sem Vasc Surg, 2011

Central venous stenosis/occlusion

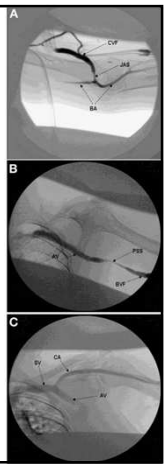
Central venous stenosis/occlusion

- Previously asymptomatic central stenosis can become symptomatic in setting of ipsilateral AV access
  - Increased risk from previous IJ or subclavian catheter use
  - Severity of venous hypertension dependent of degree of flow

Clinical Complications of High Flow AVF

- "Swing segments" are particularly prone to stenosis from high AV access flow
- High flow is associated with:
  - greater turbulence
  - stimulation of biologic factors
  - development of intimal hyperplasia

Badero O, Wasse H, Work J, AJKD, 2009



"Swing Segment" Stenosis

- AVF flow rate correlates with cephalic arch stenosis [1]
  - Flow reduction in brachial-cephalic AVF's can reduce number of interventions at the cephalic arch [2]

Miller Banding Procedure

[1] Jaberi A, J Vasc Access 2007; [2]Miller GA J Vasc Access 2010

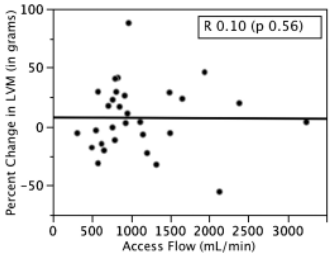
High-output heart failure

- Prevalent ESRD patients without AV access have CO of 4.6 ± 0.9 L/min *vs*. 4.3 ± 1.0 L/min in non-ESRD patients [1]
- High-output heart failure in setting of high AVF flow (3-4 L/min) has CO of 7-10 L/min [1]
- Prevalence of high-output failure is unclear
  - Data limited mostly to case reports
- Ratio of vascular access flow to CO (Qa/CO) > 0.30 may provide estimate for contribution of access to total CO [2]

[1] Wasse et al, Sem. Nephrology, 32 (6) , 2012; [2] Pandeya S, ASAIO J, 1999

Mean access blow flow does not correlate with LVM change @ 1 yr

Relationship between access blood flow and percent change in LVM.



- n=29
- 12.2% increase in LVM @ 1 yr
- No significant change in LVEDD and EF

Hiremath S et al. Nephrol. Dial. Transplant. 2010;25:2656-2661

NDT Nephrology Dialysis Transplantation

High-output heart failure

- No surgical guidelines to suggest modifications for AVF creation in setting of known, severe CHF
  - In severe (NYHA class III and IV) failure, PD should be strongly considered as first choice
  - Surgical treatment for development of high-output failure following AVF creation includes banding, distalization of inflow, ligation

[1] Wasse et al, Sem. Nephrology, 32 (6) , 2012

Surgical Approaches to avoid AVF complications

- Selection of small inflow artery
- Limit size of anastomosis
- Proximalize artery inflow

Conclusion

- Individualization of access type and AVF flow is key
  - Low-flow access can cause steal and excess CO while high-flow access may do neither
  - Depends on degree of pre-existing vascular disease and cardiac dysfunction
- Participate and direct the type of vascular access your patient receives
  - Ensure that your surgeon is aware of underlying comorbid conditions, previous vascular access history