Vascular Access

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Disclosures

- None.

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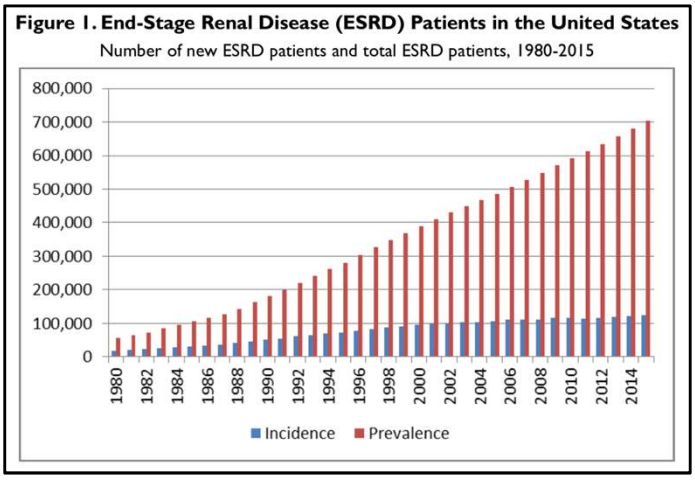
SURGERY

ESRD

- >661,000 with ESRD in the US
  - 468,000 on dialysis
  - 193,000 with functioning renal transplant
- Dialysis (As of 2013):
  - 63.7% on HD
  - 6.8% on PD
  - 29.2% with functioning kidney transplant.



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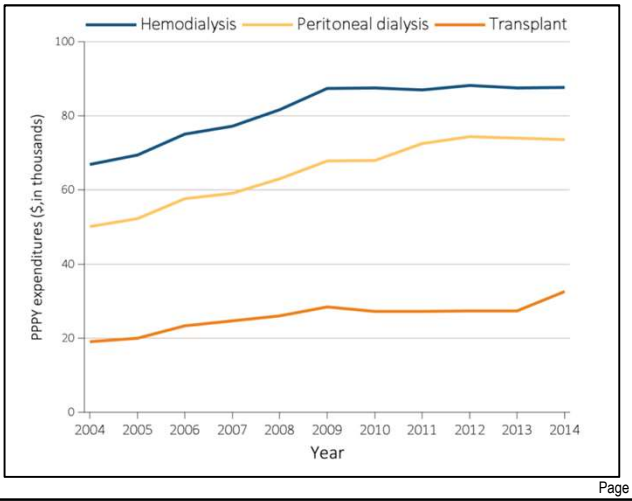
Cost

- Medicare is primary payer for 80% of ESRD patients
  - 1.3% of Medicare population with ESRD
  - 7.3% of total Medicare payments for ESRD
- In 2014,
  - Total expenditures: $32.8 Billion
  - Per patient:
    - HD – $87,638 (CVC>AVG>AVF)
    - PD – $73,612
    - Transplant - $32,586

USRDS
UNITED STATES RENAL DATA SYSTEM



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3 Types of HD access

- Arteriovenous fistula (AVF)
- Arteriovenous graft (AVG)
- Central Venous Catheters (CVC)

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Guidelines

- 1997- National Kidney Foundation(NKF)/Dialysis Outcomes Quality Initiative (DOQI → K/DOQI) – Increase AVF to 50%
- 2003- Centers for Medicare and Medicaid Service developed the Fistula First Breakthrough Initiative (FFBI)
  - Current AVF rate (as of 2013) is now 62.5%
  - Fistula First Initiative may have increase number of failures, increased number of remedial procedures, and increased time with a catheter (increase reliance on catheters)
  - ~72% of patients initiate dialysis via CVC

National Kidney Foundation
KDOQI
KIDNEY DISEASE OUTCOMES QUALITY INITIATIVE

arteriovenous
FISTULA FIRST
AVF — The first choice for hemodialysis

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Fistula First Breakthrough Initiative

Table 1 Change Concepts Adopted by Fistula First Initiative (Adapted With Permission From www.esrdncc.org)

1	Routine Continuous Quality Improvement (CQI) review of vascular access
2	Timely referral to Nephrologist
3	Early referral to surgeon for "AVF only" evaluation
4	Surgeon selection based on best outcomes and ability to provide access services
5	Full range of surgical approaches to AVF evaluation and placement
6	Secondary fistula placement in patients with AVGs
7	AVF placement in patients with catheters where indicated
8	AVF cannulation training
9	Monitoring and maintenance to ensure adequate access function
10	Education of caregivers and patients
11	Outcome feedback to guide practice
12	Modify hospital systems to detect CKD and promote AVF planning and placement
13	Support patient efforts to live the best possible quality of life through self-management

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FFCL

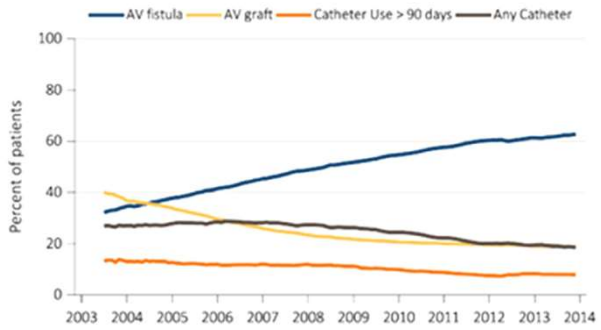

Figure 1 Vascular access trends in prevalent population in the United States in 2016 (USRDS data—www.usrds.org). USRDS, United States Renal Data System. (Color version of figure is available online.)

- FFBI has recently transitioned to FFCL (Fistula First, Catheter Last initiative) to combat the high rate of CVC use in dialysis
  - CVC rates are currently ~71.6% in dialysis initiation.
  - Prevalent rates:
    - AVF – 63%
    - AVG – 17.6%
    - CVC – 17%
- FFCL goals:
  - Prevalent rates:
    - AVF – 68%
    - 50% functioning AVF rate in incident patients
    - CVC < 10%

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Access Creation

- Key points:
  - Timely referral
  - Vessel preservation (Arteries and veins –central and peripheral)
  - Vessel selection
  - Surgical Technique
  - Close Monitoring/Salvage

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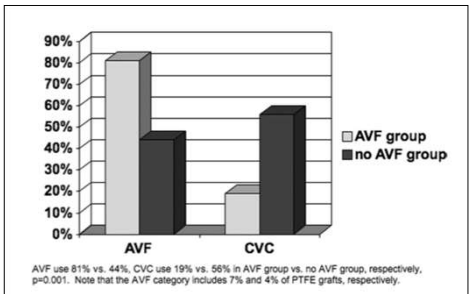
Timely Referral

ASAIO Journal 2009

Kidney Support

Outcomes of Vascular Access Creation Prior to Dialysis: Building the Case for Early Referral

Catherine L. Weber,* Ognjenka Djurdjev,† Adeera Levin,*† and Mercedeh Kiaii*



AVF use 81% vs. 44%, CVC use 19% vs. 56% in AVF group vs. no AVF group, respectively, p=0.001. Note that the AVF category includes 7% and 4% of PTFE grafts, respectively.

Figure 3. "Snapshot" of Access in Use at 6 Month Mark of Dialysis. AVF use 81% *vs.* 44%, CVC use 19% *vs.* 56% in AVF group *vs.* no AVF group, respectively, $p = 0.001$. Note that the AVF includes 7% and 4% of PTFE grafts, respectively.

- Surgical referral (GFR < 30 mL/min)
- 6 months in advance for AVF
- 3-6 weeks for AVG

ASAIO Journal: July-August 2009 - Volume 55 - Issue 4 - p 355-360

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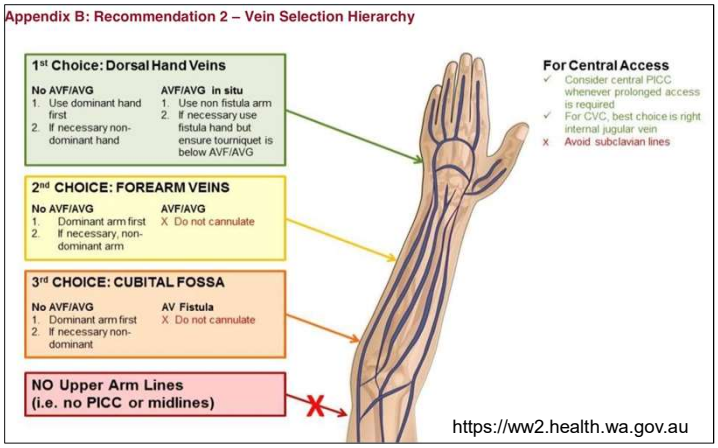
Vessel Preservation

- **PICC**
  - ~7% central stenosis
  - 38% risk of cephalic/basilic thrombosis

  Cardiovasc Intervent Radiol. 26:123-127 2003
- **Subclavian CVL**
  - 38-50% risk of central stenosis

  AJR Am J Roentgenol. 156:623-625 1991
- **Transradial access**
  - 10% rate of asymptomatic occlusion

  Cardiovasc Diagn Ther. 2017 Jun; 7(3): 305–316.



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Cephalic vein diameter, depth:
0.25 cm, wrist, 0.16 cm deep.
0.25 cm, mid forearm, 0.13 cm deep.
0.28 cm, cranial forearm, 0.29 cm deep.
0.40 cm, caudal upper arm, 0.19 cm deep.
0.25 cm, mid upper arm, 0.19 cm deep.
0.25 cm, cranial upper arm, 0.16 cm deep.

Basilic vein diameter:
0.37 cm, 4 cm caudal to antecubital fossa.
0.45 cm, antecubital fossa.
0.48 cm, mid upper arm.
0.47 cm, cranial upper arm.

Brachial vein diameter:
0.45 cm, caudal upper arm.
0.44 cm, mid upper arm.
0.53 cm, cranial upper arm.
0.13 cm, median antecubital vein
0.96 cm, axillary vein.
Normal respiratory phasicity is seen in the left internal jugular and subclavian veins.

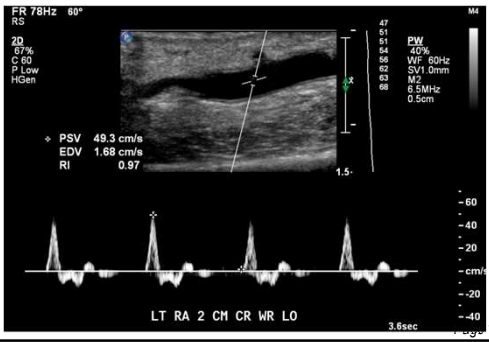
Left arm arteries (diameter, PSV):
0.27 cm, radial artery 2 cm cranial to the wrist, PSV: 0.49 m/sec.
0.45 cm, brachial artery 2 cm cranial to the antecubital fossa, PSV: 0.91 m/sec.
0.56 cm, axillary artery.

No calcification is identified within the radial artery near the wrist.

Volume flow measurements in the brachial artery 2 cm cranial to the antecubital fossa are 88, 86, and 86 cc/min.

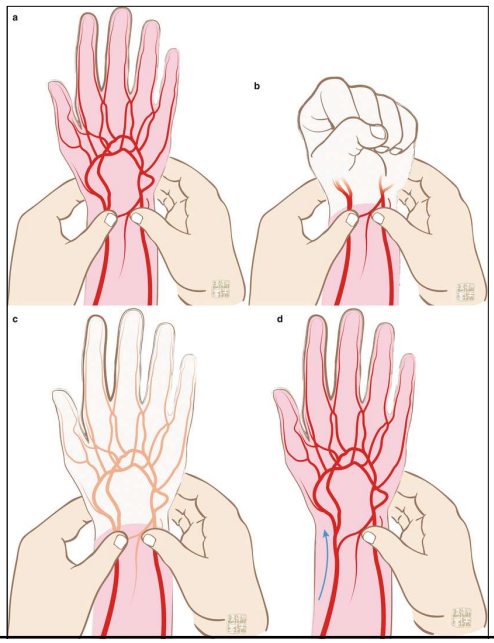
Vessel Selection

- Important to assess both arteries and veins
  - Duplex ultrasound – most common
  - CO2 venography
  - MRA/MRV
- Reassess at time of surgery



Physical Exam

- Prior access scars
- **Allen's test**
- Visible veins
- Upper extremity/Face/Neck swelling
- Venous collaterals



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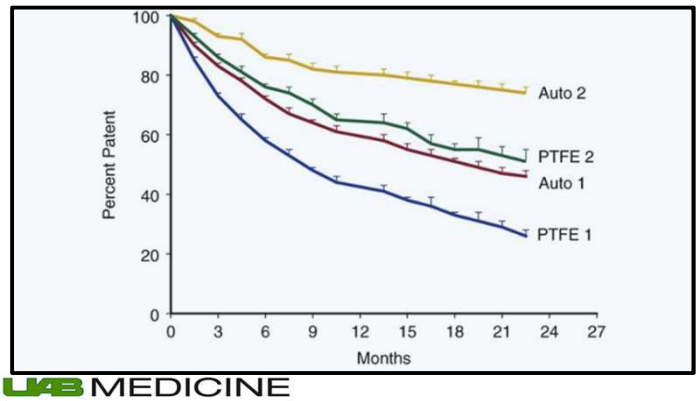
Access Site Selection

- Prefer:
  - Distal to proximal approach
  - Non-dominant arm
  - Autogenous vs. Prosthetic



Patency rates (6 months, 18 months):

Autogenous:
Primary- 72%, 51%
Secondary- 86%, 77%

Prosthetic:
Primary- 58%, 33%
Secondary- 76%, 55%

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J Vasc Surg 38:1005-1011, 2003

Factors to consider

- Age
- Diabetes
- Obesity
- Arterial anatomy
- Vein anatomy
- Patient Preference

Clinical scenarios favoring autogenous success	Young patient age
	Favorable vascular anatomy (artery >2.0mm; vein >3.0mm)
	Chronic skin diseases
	History of multiple previous access infections
	Immunosuppression/human immunodeficiency virus
	Hypercoagulability
	Multiple prior prosthetic access failures
Clinical scenarios favoring prosthetic access	Imminent need for or currently undergoing hemodialysis
	Short life expectancy
	Morbid obesity
	Unfavorable vascular anatomy
Factors that adversely influence autogenous access maturation	Diabetes mellitus (radial and ulnar-based accesses)
	Arterial diameter <2.0mm
	Calcified radial artery
	Vein diameter <3.0mm
	Congestive heart failure
	Advance patient age
	Female gender

DL Cull. Semin Vasc Surg 24:89-95, 2011.

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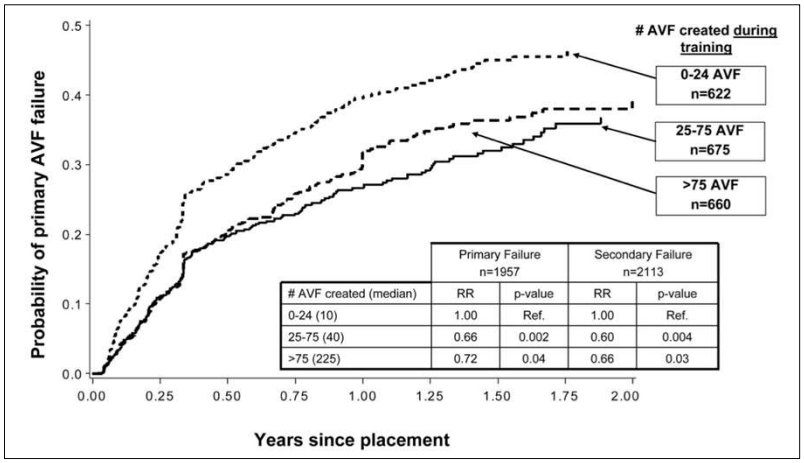
Surgical Technique

- >25 fistulas had 34% lower risk of primary AVF failure as compared to those having performed < 25 fistulas



	Primary Failure n=1957		Secondary Failure n=2113	
# AVF created (median)	RR	p-value	RR	p-value
0-24 (10)	1.00	Ref.	1.00	Ref.
25-75 (40)	0.66	0.002	0.60	0.004
>75 (225)	0.72	0.04	0.66	0.03

Data from the Dialysis Outcomes and Practice Patterns Study (DOPPS)

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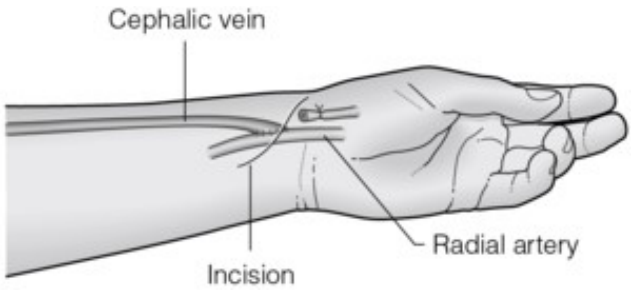
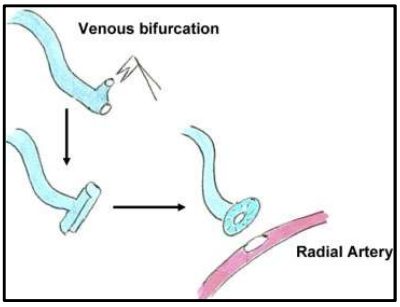
Radiocephalic AVF





Pros:
- Preserves proximal vessels
- Low incidence of steal (1-2%)
- High long-term functional rate once established (Cumulative patency up to 86% at 1 year)

Cons
- Primary failure rate of 15-59%

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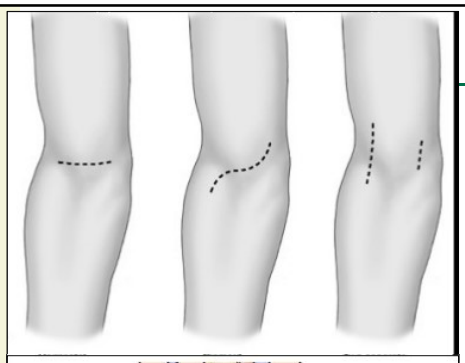
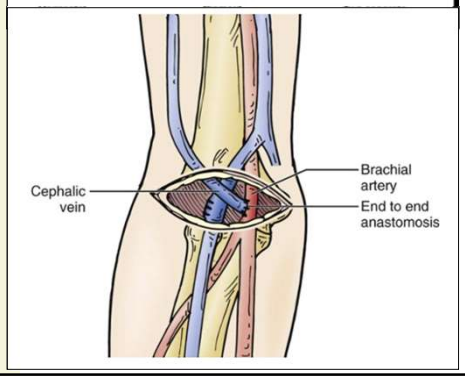
Brachiocephalic AVF





Pros:
- Higher flow rate than RC AVF
- Shorter maturation times (compared to RC AVF)
- High long-term functional use (Cumulative patency up to 77% at 1 year)

Cons:
- Technically more challenging to create
- Higher rate of steal syndrome
- Primary failure rates of 7-38%

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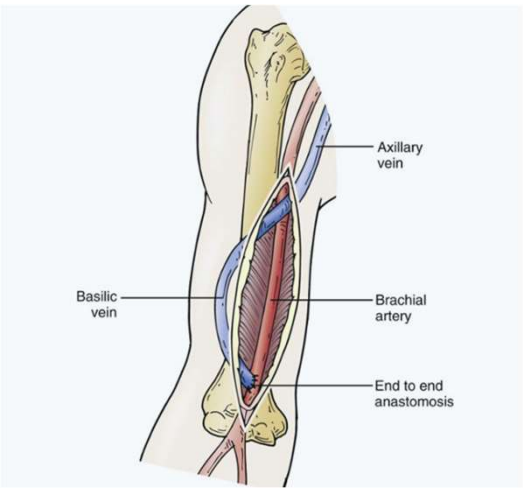
Brachiobasilic AVF

- Pros:
  - Higher flow rate as compared to RC AVF
  - More likely to mature than BC AVF
  - Cumulative 1y patency of 97% and 2y patency of 94%
- Cons:
  - 2 stages
  - 4% rate of steal syndrome
  - Primary failure rate of 20-26%
  - Longer maturation time
  - Swing site stenosis



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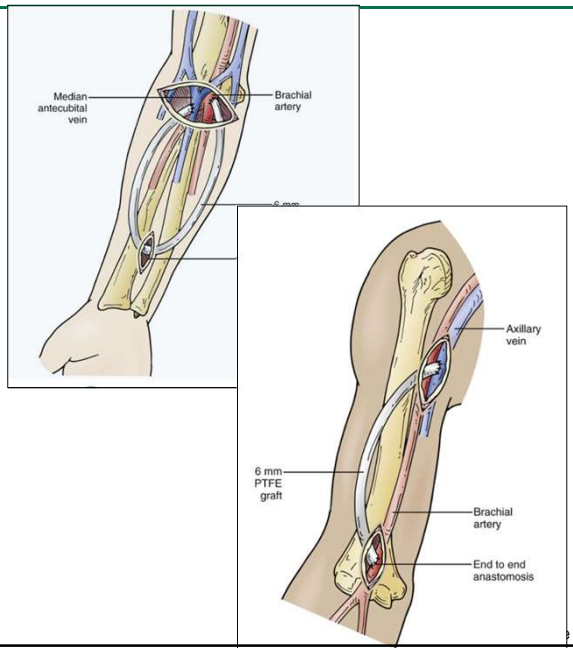
Prosthetic Access

- Pros:
  - Decreased waiting time to use (3-6 weeks)
  - Immediate use options
  - Easier to cannulate
  - More amenable to remedial procedures for a thrombosed graft
- Cons
  - Infection
  - Decreased long-term patency



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Maturation

- Rule of 6's
  - 6 mm vein diameter
  - 6 mm or less in vein depth
  - 600 mL/min blood flow
  - 6-10 cm straight segment for access

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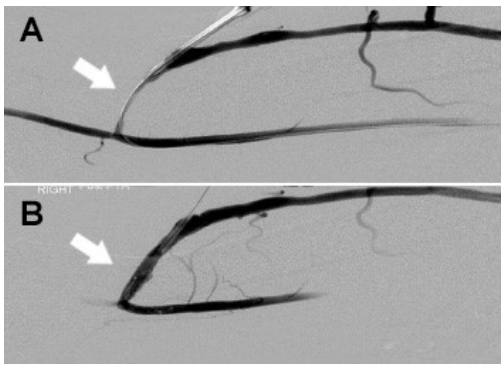
Maturation assistance

- Fistulogram
- Balloon-assisted maturation (BAM)
- Side-branch ligation
- Superficialization vs. suction lipectomy
- Central vein stenosis
- Antiplatelet/Anticoagulation



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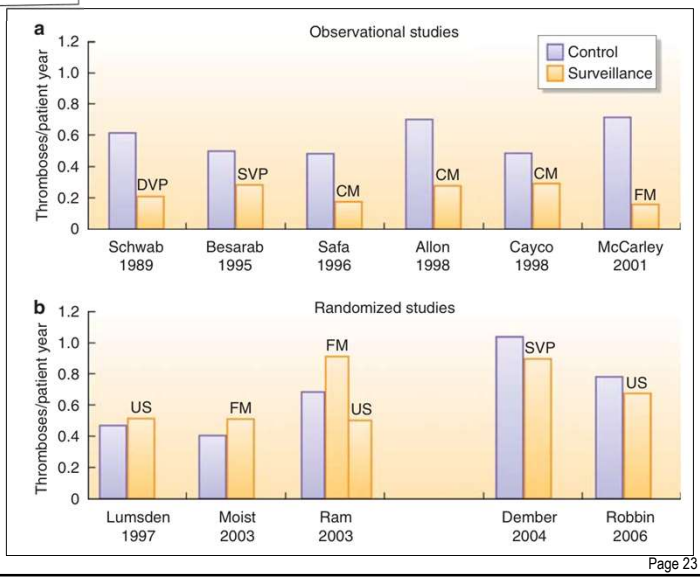
Duplex Ultrasound Surveillance

Vascular access surveillance: an ongoing controversy

William D. Paulson[1], Louise Moist[2] and Charmaine E. Lok[3]

[1]Charlie Norwood VA Medical Center and Nephrology Section, Department of Medicine, Georgia Health Sciences University, Augusta, Georgia, USA; [2]Division of Nephrology, University of Western Ontario, London, Ontario, Canada and [3]Department of Medicine, Division of Nephrology, The Toronto General Hospital and The University of Toronto, Toronto, Ontario, Canada

- The benefit of duplex surveillance fails to hold up in rigorously controlled trials.



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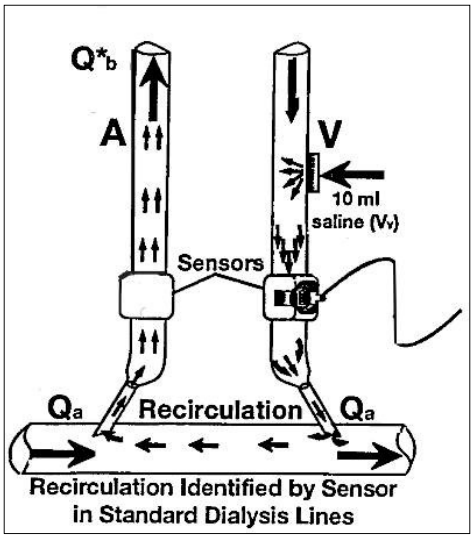
Detecting the Failing Access

- Urea clearance with dialysis – Kt/V
  - K – rate of urea clearance (pre + post measurements)
  - t – duration of dialysis
  - V – urea distribution volume
- Recirculation (retreatment of blood already filtered) – due most often to venous outflow stenosis
- Venous static pressure – measure from the efferent needle with the dialysis pump off (>50% of the MAP is considered abnormal)
- Flow Measurement – Measures flow velocity by injecting isotonic saline into the blood stream



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Complex Access

- Up to 7% of HD access procedures occur in a location other than the upper extremity
- This number is likely increasing as more patients are outliving their access.

Am J Kidney Dis. 2015 Jun;65(6):905-15

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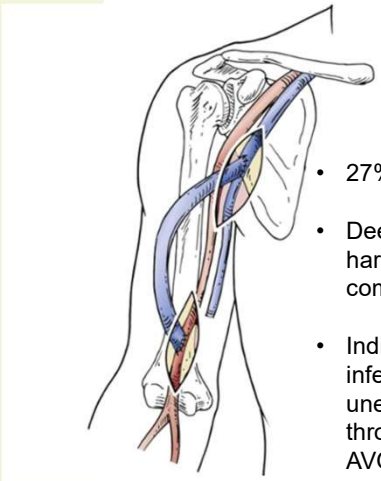
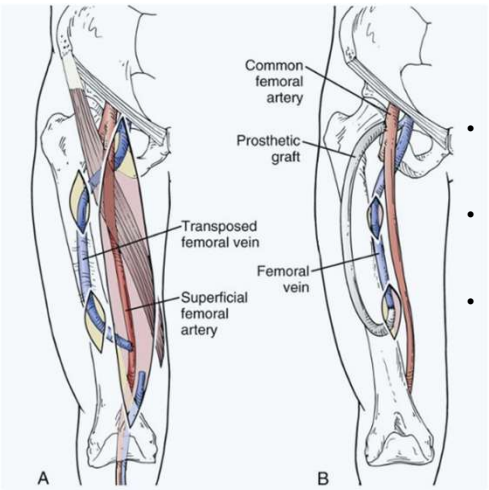
Autogenous Transposition

Brach-ax AV graft with reversed translocated femoral vein



- 27% risk of steal
- Deep vein harvest complications
- Indicated for infection or unexplained thrombosis of UE AVG

Femoral Vein Transposition



- High risk of steal syndrome (~32%)
- 28% wound complications
- 78% and 87% primary and secondary patency at 1 year

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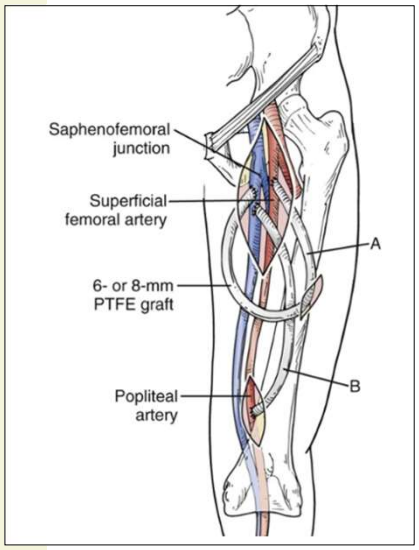
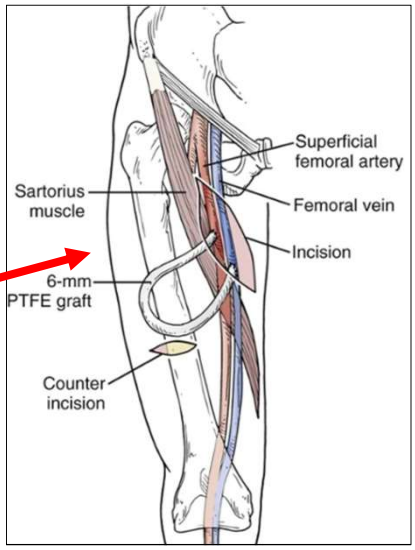
Prosthetic Thigh AV Graft



- Patency rates are similar to slightly better than for UE prosthetic.
- Infection rates are as high as 41%. *(J Vasc Surg.* 2004. 39:381-386.)
- Infection rates are lower for midthigh looped AVG (~21%) (*Am Surg.* 2006. 72:825-828.)



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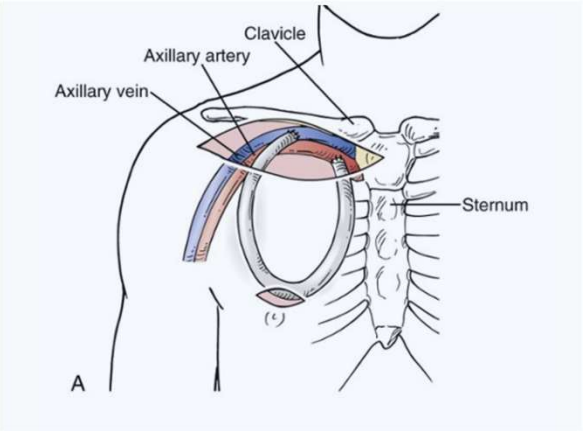
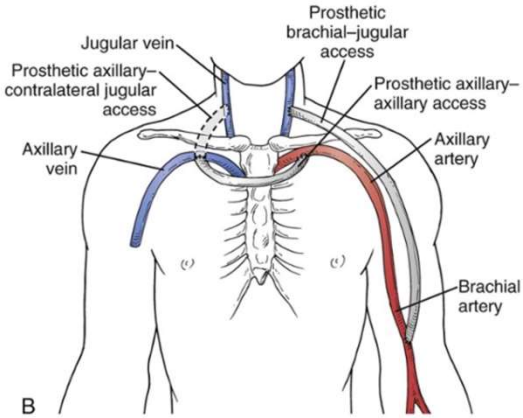
CHEST WALL ACCESS





- Useful in obese patients
- Secondary Patency rates as high as 80% at 2 years
- Low risk of steal syndrome

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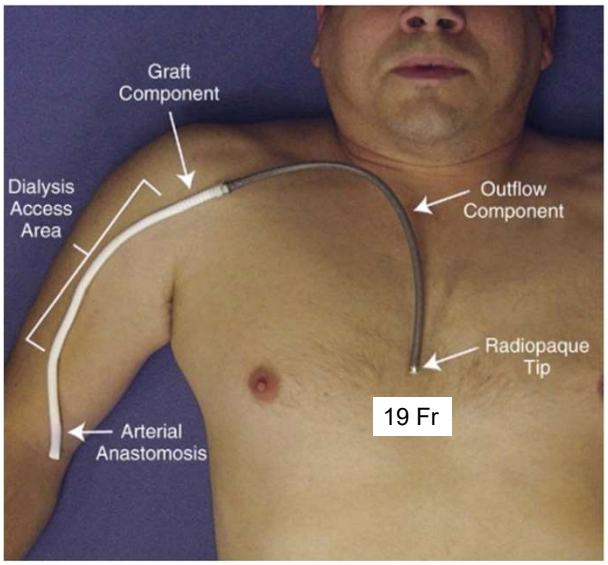
HeRO Graft

- Indicated for central venous stenosis or occlusion
- Brachial artery needs to be 3mm or greater
- Primary patency of 49% and secondary patency of 91% at 1 year. (*Eur J Vasc Endovasc Surg. 2012* 44:93-99.)



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Complications

- Bleeding
- Infection
- Venous Hypertension
- CHF
- Pseudoaneurysm
- Thrombosis
- Neuropathy
- Steal syndrome

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Steal Syndrome

- ~1% of autogenous access in the forearm
- ~9-15% of prosthetic access off the brachial artery

- Grade 0: No steal
- Grade 1: Mild – cool extremity, few symptoms
- Grade 2: Moderate – intermittent ischemia during dialysis
- Grade 3: Severe – Ischemic rest pain, tissue loss

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Steal Diagnosis

- Mainly clinical
- Duplex ultrasound
- Digital PPG
- Evaluate for arterial inflow/outflow stenosis first (arteriogram)

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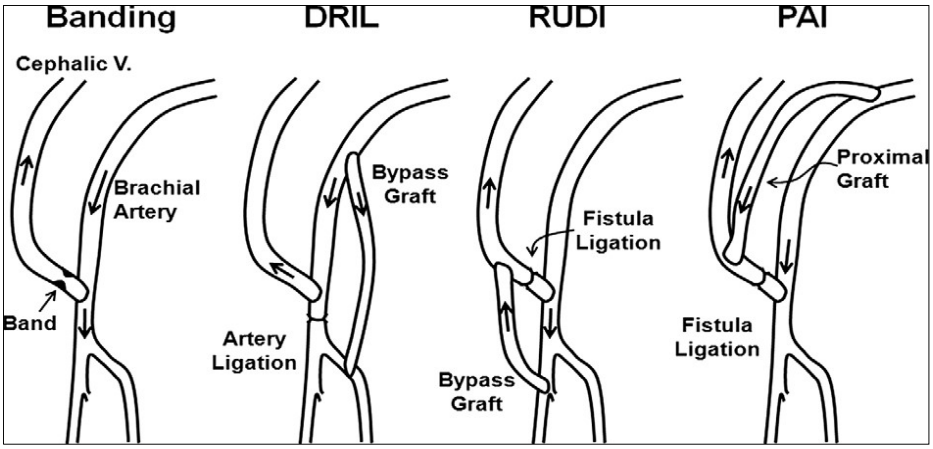
Vascular Medicine 2009; 14: 371–376

Steal Treatment



- High occlusion rate
- Use intraop PPG

- Hand depends on bypass
- 95-100% limb salvage
- 82-95% 1 yr. access patency

- Hand relies on native circulation
- Higher rate of access thrombosis
- 82.7% success, 10.7% steal ongoing, 7.6% access thrombosis at 1 yr

- Hand not reliant on bypass
- 65% complete resolution, 26% improvement, 9% persistant sx

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Ischemic Monomelic Neuropathy

- 0.5% of dialysis access creations
- Diabetics
- Brachial artery origin
- Hx of peripheral neuropathy
- Acute pain, numbness, paralysis in an otherwise well perfused hand
- LIGATE!

Beathard G.A. (2017) Ischemic Monomelic Neuropathy. In: Yevzlin A., Asif A., Redfield III R., Beathard G. (eds) Dialysis Access Cases. Springer, Cham

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Percutaneous AVF

A Review of the Current Status of Percutaneous Endovascular Arteriovenous Fistula Creation for Haemodialysis Access

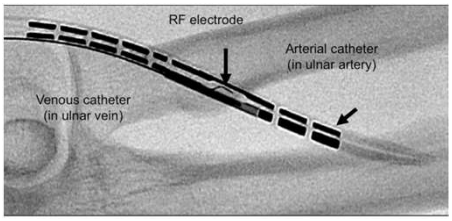
Robert G. Jones[1] · Robert A. Morgan[2]

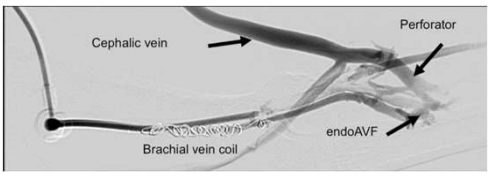
Table 2 Data summary

Author year	Device	Patients	Technical success (%)	Maturation 90 day (%)	Time 2-needle	Patency 12 months
Rajan (2015)	EverLinQ	33	97			NA
Lok (2017)	EverLinQ	60	98	87	112	84%
Radosa (2017)	EverLinQ	8	100			
Hull (2017)	Ellipsys	26	88			NA
Hull (2018)	Ellipsys	107	95	86	114	87%
Mallios (2018)	Ellipsys	34	97	97	35	NA

	EverlinQ [12] Lok et al.	Ellipsys [14] Hull et al.
Patients	60	107
Transposition	5(8)	28 (26)
Brachial vein embolization	5 (8)[a]	34 (32)
Cubital vein ligation	0	33 (31)
PTA	2 (3)	77 (72)

[a]100% of patients in this series had brachial vein embolization during the index procedure. The five cases here represent additional secondary embolizations





- 1 year primary patency 69%, secondary patency 84%

Cardiovasc Intervent Radiol (2019) 42:1–9

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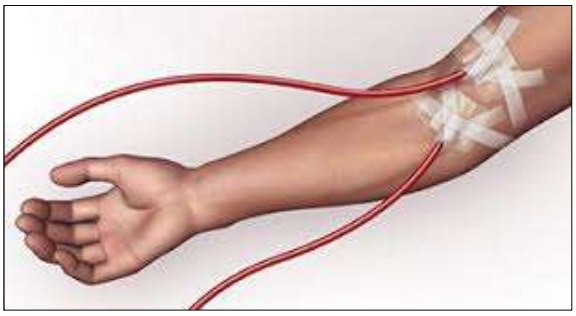
Too early to tell!

Conclusion

- Early Referral (GFR < 30mL/min/1.73m^2) is essential
- Autogenous access placed early (~6 months prior to dialysis)
- Vessel preservation (distal to proximal)
- Complex access toolbox
- Early recognition and treatment of both failing access and complications



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Thank you

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