**Objectives**

- Definition of mature AVF
- Physiology of AVF maturation
- Endovascular interventional procedures to improve maturation

**Study of Size and Flow**

- If fistula diameter was 0.4 cm or greater, the chance that it would be adequate for dialysis was 89% versus 44% if it was less.
- If fistula flow was 500 ml/min or greater, the chance that it would be adequate was 84% versus 43% if it was less.
- Combining the two variables, the chance that it would be adequate was 95% versus 33% if neither of the criteria were met.
- Experienced dialysis nurses had an 80% accuracy in predicting the ultimate utility of a fistula for dialysis.

**KDOQI 2006**

**Rule of 6’s**

- Access flow of >= 600 ml/min
- Depth of <= 6mm from skin surface
- Fistula vein diameter of >= 6mm
- 6 weeks after creation

**What defines a mature fistula?**

- Enough blood flow to avoid recirculation
- Distal limb perfusion must be maintained
- Cannulatable segment should be straight, thick walled, superficial, adequate caliber
- Unimpeded drainage into the central veins
1. Routine CQI review of vascular access
2. Timely referral to nephrologist
3. Early referral to surgeon for “AVF” only
4. Surgeon selection
5. Full range of surgical approaches
6. Secondary AVF’s in AVG pts
7. AVF evaluation in all catheter pts
8. Cannulation training
9. Monitoring and maintenance
10. Continuing education
11. Outcomes feedback

How does one achieve a mature/functional fistula?

Preoperative plan
- Vein preservation
- Clinical exam
- Vessel mapping

Operative/surgical issues
- Surgical expertise and center effects
- Pharmacology

Postoperative follow-up/intervention

ASDIN Recommendations for venous access in CKD pts

- Use dorsal hand veins for peripheral access and phlebotomy
- Use the Internal Jugular vein for central access
- Avoid the Subclavian vein
- Avoid PICC’s (peripherally inserted central catheters)


Which CKD 3 patients need vein protection?

Relationship Between Predicted Creatinine Clearance and Proteinuria and the Risk of Developing ESRD in Okinawa, Japan

The Case for Using Albuminuria in Staging Chronic Kidney Disease

Relationship Between Kidney Function, Proteinuria, and Adverse Outcomes
JAMA 303: 423-429, 2010

Preoperative Strategy

Preservation of veins – important
Semin Dial 22:186-191

Vascular mapping – imperative
Robbins et al. Radiology 222: 59-64, 2002
Duplex sonography

Plethysmography

Comparison of Morphological and Functional Characteristics Evaluated by Duplex Sonography Before AVF Construction Between Two Groups

<table>
<thead>
<tr>
<th></th>
<th>Group A (n = 93)</th>
<th>Group B (n = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Artery baseline examination</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDA (cm)</td>
<td>0.264 ± 0.065*</td>
<td>0.162 ± 0.086</td>
</tr>
<tr>
<td>Thickness of artery wall (cm)</td>
<td>0.0273 ± 0.015</td>
<td>0.0302 ± 0.016</td>
</tr>
<tr>
<td>QA (mL/min)</td>
<td>54.50 ± 22.81*</td>
<td>24.11 ± 16.81</td>
</tr>
<tr>
<td>RI</td>
<td>1.15 ± 0.13</td>
<td>1.16 ± 0.13</td>
</tr>
<tr>
<td><strong>Artery at RH</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDA (cm)</td>
<td>0.294 ± 0.075*</td>
<td>0.171 ± 0.073</td>
</tr>
<tr>
<td>QA (mL/min)</td>
<td>90.92 ± 42.90*</td>
<td>33.09 ± 26.82</td>
</tr>
<tr>
<td>RI</td>
<td>0.50 ± 0.13*</td>
<td>0.70 ± 0.17*P&lt; 0.01</td>
</tr>
</tbody>
</table>

RI=Resistance Index   RH=Reactive hyperemia

Success Rate of Newly Constructed AVFs in Patients Grouped by Morphological and Functional Characteristics of Vessels Established Before Surgery

<table>
<thead>
<tr>
<th>Vessel Characteristics</th>
<th>No. of Patients</th>
<th>Success Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDA (cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;0.16</td>
<td>91 (78)</td>
<td>85/91 (93)†</td>
</tr>
<tr>
<td>≤0.16</td>
<td>25 (22)</td>
<td>8/25 (32)</td>
</tr>
<tr>
<td>RI at RH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;0.7</td>
<td>85 (73)</td>
<td>81/85 (95)†</td>
</tr>
<tr>
<td>≥0.7</td>
<td>31 (27)</td>
<td>12/31 (39)</td>
</tr>
</tbody>
</table>

†=P<0.01
RI=Resistance Index   RH=Reactive hyperemia
Forearm Venous Distensibility Predicts Successful Arteriovenous Fistula
Joke van der Linden et al. AJKD 47:1013-1019, 2006

Measured with strain gauge plethysmography

**P = 0.003.  N=27**

Choice of surgeon and surgical center:

Pharmacological
Dialysis Access Consortium (DAC)
887 pts  RCT (multi-center, double-blinded) of clopidigrel (Plavix) 75mg daily x 6wks vs placebo

<table>
<thead>
<tr>
<th></th>
<th>Thrombosis</th>
<th>Suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clopidigrel</td>
<td>12.2%</td>
<td>61.8%</td>
</tr>
<tr>
<td>Placebo</td>
<td>19.5%</td>
<td>59.5%</td>
</tr>
</tbody>
</table>


AV Fistula

Primary failure rate
40%

Physiology of maturation
Blood flow in artery baseline: 60 cc/min
One day after avf creation: 400 cc/min
30 days after 500- 800cc/min
90 days same

Robbin et al. Radiology 220: 35-64, 2002
When to intervene

KDOQI 2006 update: CPG 3.2
"At a minimum, all newly created fistulae must be physically examined by using a thorough systematic approach by a knowledgeable professional 4 to 6 weeks postoperatively to ensure appropriate maturation for cannulation."

Causes of fistula immaturity or "early failure"

Arterial Disease and Stenoses

Juxta-anastomotic lesions

Venous Disease and Stenoses

Thrombosis

Accessory veins

Vein is deep or tortuous

Surgical Salvage options

1. Excision of stenotic lesion with simple primary vein re-anastomosis
2. Patch or interposition vein segment
3. Prosthetic segment
4. Proximalization of arterial inflow
5. Superficialization
6. New AVF in a new location

See references

Endovascular Salvage procedures for immature AVF

<table>
<thead>
<tr>
<th>salvage rate</th>
<th>primary patency rate</th>
<th>multiple rate</th>
<th>pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beathard 2003</td>
<td>82%</td>
<td>75%</td>
<td>78%</td>
</tr>
<tr>
<td>Nassar 2006</td>
<td>83%</td>
<td>65%</td>
<td>73%</td>
</tr>
<tr>
<td>Clark 2006</td>
<td>88%</td>
<td>34%</td>
<td>42%</td>
</tr>
<tr>
<td>Falk 2006</td>
<td>74%</td>
<td>na</td>
<td></td>
</tr>
<tr>
<td>Song 2006</td>
<td>95%</td>
<td>28%</td>
<td>na</td>
</tr>
<tr>
<td>Miller 2009</td>
<td>96%</td>
<td>39%</td>
<td>na</td>
</tr>
</tbody>
</table>

Endovascular Interventional Procedures

Angioplasty

PTA of stenoses

BAM (balloon angioplasty maturation)

Stents

Thrombectomy

Coil embolization or ligation of accessory veins

Flow re-routing

Aggressive approach to salvage non-maturing AVF:
A retrospective study with follow-up.

Sheathless access

Staging procedures

Long balloon lengths (4-10 cm)

controlled arterial inflow to limit extravasation
Highlights:
118/122 successful fistula maturations
1.6-2.6 mean # procedures/per fistula
Secondary patencies 72-77% at 12 months

Percutaneous dilation of the radial artery in nonmaturing autogenous radial-cephalic fistulas for hemodialysis

74 consecutive patients: 2002-2008, single center France
69% DM
23% smokers
64% CAD
46% PAOD
32% lower limb amputations

102 pts excluded had arterial anastomotic lesions – surgical revision
321 pts excluded had only venous stenoses or thromboses.

Highlights:
Technical success 73/74 cases
PTA ruptures 13 (17%)
2 stent repairs
Hand ischemia 5 (7%)
dorsal radial artery ligation
Assisted patency 11 mos/14 mos
96% 94%

Highlights:
No sedation, only local lidocaine
90% diluted contrast for 6 pts not on dls
Brachial and radial arterial cannulations were the most common accesses for the procedures 4F sheath
No anticoagulant
frequent saline flushes
Tourniquet to decrease arterial pressure

Highlights:
“All arterial stenoses dilated to 4mm at 25atm”
- cutting balloon PTA refractory lesions
Mean artery stenosis length 6.8 cm

Juxta-anastomoticstenosis
Percutaneous Transluminal Angioplasty

Post Angioplasty

Mid cephalic vein fistula severe stenosis

Post Angioplasty

Figure 1. A sample of two vascular lesions that were encountered during salvage procedures on “failing to mature” arteriovenous fistulas (AVF).


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Accessory vein
Conclusion and Summary

AVF: Primary Failure Rate 40%

Pre-operatively:
- continued vein preservation strategy
- better refinement of our mapping

Operative/Surgical:
- new drug/molecules (ex.: pancreatic elastase - induces vein dilatation by promoting breakdown of collagen)

Post-operatively:
- endovascular interventions when applied appropriately and judiciously can be very successful in converting the immature fistula into a functional HD access
Fistula First: Impact on AVF, AVG and Catheters
An Update

Anil K. Agarwal, MD, FASN, FACP
Professor of Internal Medicine
Director, Interventional Nephrology
The Ohio State University College of Medicine and Public Health
Columbus, Ohio

Objectives

• Provide background of Fistula First Breakthrough Initiative
• Discuss improvement in AVF rates with FF
• Describe impact of FF on AVG and Catheters
• Has FF increased catheter rates?
• Consider strategies to achieve goals of ‘Fistula First and Catheter Last’


Fistula First: History

• FF Breakthrough Initiative sponsored by CMMS
• Also known as National Vascular Access Improvement Initiative (NVAII)
• Developed in 2003, launched in 2004 through 18 ESRD networks nationwide

FF: Key Recommendations

• Autogenous AVF is the most optimal access for hemodialysis (HD)
• FF did not advocate ‘Fistula for All’, only a consideration and placement of AVF when feasible
• FF ‘Change Concepts’ included catheter reduction strategies, recommending:
  • ‘AVF placement in patients with catheters when indicated’
  • ‘AVF placement in patients with catheters when indicated’
• It was the expectation that the AVF will increase, and the catheters will be reduced

FF: Impact on AVF

• Achieved goal of 40% prevalent AVF in 2005- ahead of 2006 schedule
• In first 4 years of FF initiation, by January 2008, AVF prevalence increased by ~50% (from 32% to 49%)
• New stretch goal of 66% prevalent AVF by 2009- considered conservative in comparison to many other developed countries
• Prevalence of AVF is continuing to rise with some variation among the networks
Fistula Rates By Network: 2002 and 2008

Prevalent AVF: Nov 2009 (FF Dashboard)

State of Access:
August 2009 (FF Dashboard Summary)

Incident Catheters: USRDS 2009 Report

- 2007 data showed that 81% of patients started dialysis with catheter
  - Attributed to multiple factors
    - late referral to nephrologists
    - patient resistance
    - co-morbidities
    - poor access to care
  - Could preoccupation in trying to mature AVF have contributed to the rise in catheter rates?
Tunneled Catheter: No TIME safety
Central Vein Stenosis & Infection

IJV stenosis occurring 1 WEEK after temporary catheter placement!!!
IJV+SCV thrombosis & bacteremia occurring 1 WEEK after tunneled catheter placement!!!

Slide courtesy: Tony Samaha MD

Has the Fistula First Breakthrough Initiative
Caused an Increase in Catheter Prevalence?
Lawrence M. Spergel,
Clinical Chair: A-V Fistula First Breakthrough Initiative
Dialysis Management Medical Group, San Francisco, California

Seminars in Dialysis
Vol 21, No 6 (November–December)
2008 pp. 550–552

Trends in AVF and CVC Prevalence Since FF
2003-2007

Catheter Rates Around FFBI Inception

Continuing Impact of FF On Access Type

Changes in Prevalent AV Access 2007-2009

<table>
<thead>
<tr>
<th>AV Access</th>
<th>Jan 2007 (%)</th>
<th>Mar 2009 (%)</th>
<th>Diff (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVF</td>
<td>45.2</td>
<td>52</td>
<td>6.8 (6.2, 7.3)</td>
</tr>
<tr>
<td>Cath &gt; 90 days</td>
<td>12</td>
<td>10.9</td>
<td>-1.1 (-4.4, -0.7)</td>
</tr>
<tr>
<td>Cath &lt; 90 days</td>
<td>6.9</td>
<td>5.9</td>
<td>-0.9 (-1.2, -0.7)</td>
</tr>
<tr>
<td>AVF &amp; Cath</td>
<td>7.8</td>
<td>7.5</td>
<td>-0.3 (-0.6, -0.1)</td>
</tr>
<tr>
<td>AVG &amp; Cath</td>
<td>2.2</td>
<td>1.9</td>
<td>-0.3 (-0.6, -0.2)</td>
</tr>
</tbody>
</table>

Spergel, LM. Seminars in Dialysis, 2008;21:550–552

SPECIAL ARTICLE

Balancing Fistula First With Catheters Last

Eduardo Lacson Jr, MD, MPH, J. Michael Lazarus, MD,
Jonathan Himmelfarb, MD, T. Alp Ikizler, MD, and Raymond M.
Hakim, MD

Barriers to Catheter Reduction

• High rates of primary AVF failure
• Long maturation times
• Need for repeated interventions to salvage immature AVF

Suggestions to improve AVF rates

• Focus on early creation of AVF in late CKD
• Early salvage of 'non-maturing' AVF
• Maintenance of AVF by dialysis staff and the interventionalist if needed
• Creation of Secondary AVF
• Avoidance of placing catheters
• Removing the catheters as soon as possible
• Use of alternative 'bridges' to AVF- PD, AVG

Is the FF Target of 66% for Prevalent AVF Feasible?

SUMMARY

• FFBI has significantly impacted the culture of vascular Access in US
• AVF rates have increased and continue to improve across all the networks
• AVG rates have decreased
• Catheter rates have remained stable
• Reinforced strategies- including pre-dialysis AVF placement, early intervention for non-maturing AVF and placement of secondary AVF will be needed to improve AVF rates further

SUMMARY

• Emphasis on catheter reduction is becoming the new focus in conjunction with improving AVF utilization
• Strategies for 'Fistula First' must continue to be balanced with 'Catheter Last' approach
Vascular Access & Mortality

Monnie Wasse, MD, MPH
Emory University
Renal Division & Interventional Nephrology

Infection-related death by vascular access type

- CVC vs. AVF: OR=3.0
- Diabetics: CVC vs AVF: OR = 10.1
- CVC vs. AVG: OR=2.2
- AVF=AVG

2002, Pastan et al: Network 6, n=7500 prevalent patients

Infection-related death by vascular access type

- CVC’s are associated with significantly greater risk of infection & infection-related hospitalization than AVF and AVG
- AVG vs. AVF:
  - AVG infection rate 9.5% vs. 0.9% in AVF (p<.001) \(^1\) in retrospective study n=1700
  - AVG infection-related hospitalization is greater than AVF\(^2\)
- Non-diabetic AVF and AVG patients have similar risk of infection-related mortality

\(^1\) Schild, 2008, J Vasc Access; \(^2\) Pisoni, 2009, AJKD

Financial disclosure: None
Catheters are associated with increased infection-related hospitalization & death

Cardiovascular-related death by vascular access type: Incident patients

- At Dialysis initiation
  - AVF = CVC
  - AVG = CVC
  - Lack of association likely due to high rate of death within first 90 days from other causes

- 90 days after dialysis start
  - AVF vs CVC: HR = 0.69
  - AVG = CVC
  - Possibly related to reduction in systemic inflammation

2008, Wasse et al, USRDS CPM data, n=4854 incident patients

Cardiovascular-related death by vascular access type: Prevalent patients

- Non-diabetic
  - CVC vs AVF: RR = 1.38
  - AVG = AVF

- Diabetic
  - CVC vs AVF: RR = 1.85
  - AVG vs AVF: RR = 1.35

2001; Dhingra et al, USRDS n=5500 prevalent patients

Cardiovascular-related death by vascular access type

- Incident ESRD patients
  - CVC use increases risk of CV-related death 90 days after dialysis start
  - No difference in CV-death between AVF and AVG

- Prevalent ESRD patients
  - CVC use has greatest risk of CV-related death, followed by AVG use among diabetics
  - No difference in CV-death between non-diabetic AVF and AVG users

Vascular access & all-cause mortality

- Non-diabetic
  - CVC vs AVF: OR = 1.7
  - AVG = AVF

- Diabetic
  - CVC vs AVF: OR = 1.54
  - AVG vs AVF: OR = 1.4

2001; Dhingra et al, USRDS n=5500 prevalent patients

Vascular access & all-cause mortality

- CVC vs AVF: 40% greater risk of death
- CVC vs AVG: 30% greater risk of death
- AVF = AVG
- Diabetics had no increased risk of all-cause death

2002, Pastan et al: Network 6, n=7500 prevalent patients
Vascular access & all-cause mortality: Older patients

- CVC vs. AVF:
  - OR = 2.15 (90 days)
  - OR = 1.85 (6 months)
  - OR = 1.70 (1 year)
- CVC vs. AVG: 46% increased risk of death
- AVF vs AVG: 46% increased risk of death

2003, Xue et al; Medicare incident, n=66,600 ESRD patients > 67 yo

Pisoni, 2009, DOPPS data, 28,200 ESRD patients

What about change in vascular access & all-cause mortality?

- Change from CVC to permanent access
  - When transitioning from CVC to either AVF or AVG, reduced mortality by 21%
  - Change from AVF or AVG to CVC increased risk of mortality by more than 2-fold (HR 2.12, P < 0.001)

2009 Lacson et al, Fresenius n=79,500 ESRD patients

Additional factors to consider: QOL

- Quality of life
  - Random sample 1563 incident ESRD patients
  - AVF, AVG QOL > CVC QOL
    - Better health perception, energy, sleep and lower burden of ESRD on daily life with AVF vs. CVC
    - Better energy, lower burden ESRD on daily life among patients with AVG vs. CVC
    - No significant differences in QOL between AVF and AVG patients

1Wasse et al, CJASN, 2007

Additional factors to consider: cost

- 2010 USRDS Annual Data Report
  - per person per year total costs
    - CVC $72,729
    - AVG $60,000
    - AVF $60,000
Conclusion

Vascular access type influences mortality; CVC’s are worse in every metric. AVF and AVG are comparable in cardiovascular mortality among non-diabetics, QOL.