Advances in AVF Maturation

ASDIN 2010 Annual Meeting
Orlando, FL

Jeffrey Hoggard MD FACP FASN
Capital Nephrology Associates
Raleigh, NC

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 flowwas 500 ml/minor 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 nurseshad an 80 % accuracy in predicting the ultimate utility of a fistula for dialysis

Robbin. Radiology 225:59-64, 2002

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?

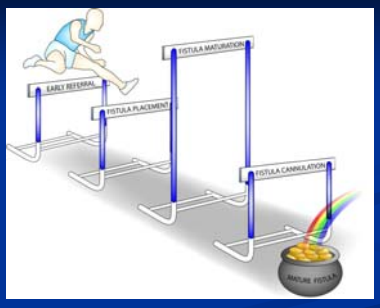
Enough blood flow to avoid recirculation

Distal limb perfusion must be maintained

Cannulatable segment should be straight, thick walled, superficial, adequate caliber

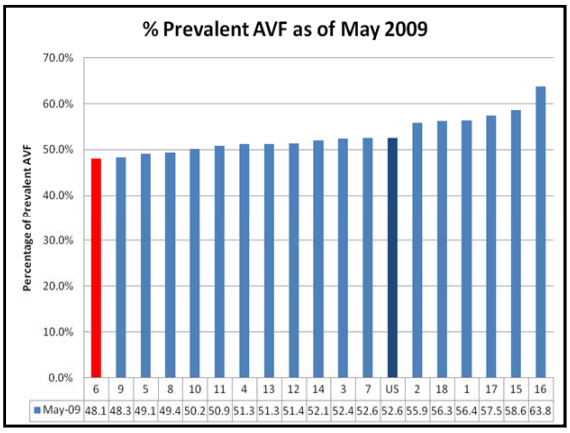
Unimpeded drainage into the central veins

Figure 2. The "fistula hurdle



Allon, M. Clin J Am Soc Nephrol 2007;2:786-800

CJASN



Fistula First Change Concepts

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 effect
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)

Hoggard et al. Semin Dial 21: 186-191, 2008

Which CKD 3 patients need vein protection?

Relationship Between Predicted Creatinine Clearance and Proteinuria and the Risk of Developing ESRD in Okinawa, Japan
AJKD 44: 806-814, 2004.

The Case for Using Albuminuria in Staging Chronic Kidney Disease
J Am Soc Nephrol 20: 465-468, 2009.

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

Preoperative Strategy

Preservation of veins – important

Semin Dial 21: 186-191

Vascular mapping – imperative

Robbin et al. Radiology 225: 59-64, 2002
Silva et al. J VascSurg 27: 302-08,1998
Ascher et al. J VascSurg 31: 84-92, 2000
Huber et al. J VascSurg 36: 452-59, 2002
Robbin et al. Radiology 217: 83-88, 2000
Karyakayali et al. Ann VascSurg 21: 481-9, 2007
Asif et al. Semin Dial 18: 239-42, 2005
Kian et al. Kidney Int 69: 1444-9, 2006

Duplex sonography

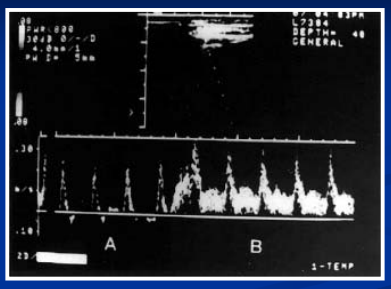
Malovrh M, Native Arteriovenous Fistula: Preoperative Evaluation. Am J Kidney Disease, 39: 1218-1225, 2002.

Plethysmography

Linden et al. Forearm Venous Distensibility Predicts Successful Arteriovenous Fistula. Am J Kidney Disease, 47:1013-1019, 2006.

Fig. 3

Doppler signal of artery(A) before and (B) at RH



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

	Group A (n = 93)	Group B (n = 23)
Artery baseline examination		
IDA (cm)	0.264 ± 0.065*	0.162 ± 0.066
Thickness of artery wall (cm)	0.0273 ± 0.015	0.0302 ± 0.016
QA (mL/min)	54.50 ± 22.81*	24.11 ± 16.81
RI	1.15 ± 0.13	1.16 ± 0.13
Artery at RH		
IDA (cm)	0.294 ± 0.075*	0.171 ± 0.073
QA (mL/min)	90.92 ± 42.90*	33.09 ± 26.82
RI	0.50 ± 0.13*	0.70 ± 0.17 *P< 0.01

RI=Resistance Index RH=Reactive hyperemia

N= 116

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

Vessel Characteristics	No. of Patients	Success Rate
IDA (cm)		
>0.16	91(78)	85/91 (93)†
≤0.16	25 (22)	8/25 (32)
RI at RH		
<0.7	85 (73)	81/85 (95)†
≥0.7	31 (27)	12/31 (39)

†=P<0.01

RI=Resistance Index RH=Reactive hyperemia

Fig. 1

Normal Doppler signal of vein

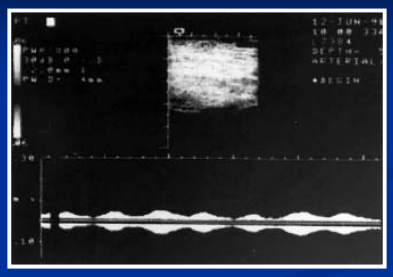
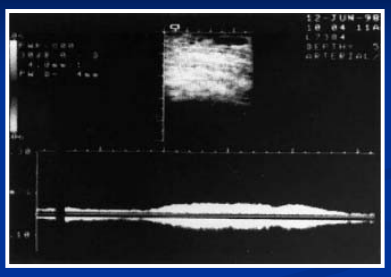


Fig. 2

Increase in venous flow at deep inspiration



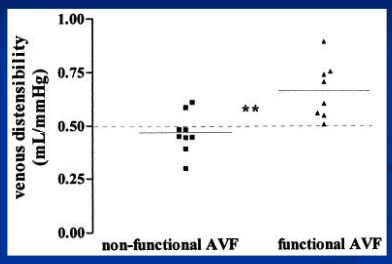
Forearm Venous Distensibility Predicts Successful Arteriovenous Fistula

Joke van der Linden et al. AJKD 47:1013-1019, 2006

Measured with strain gauge plethysmography

Fig 1

Comparison of forearm venous distensibility in patients with functional and nonfunctional AVFs



**P = 0.003.

N=27

Choice of surgeon and surgical center:

Dixon et al. Am J Kidney Dis 39:92-101, 2002
Pisoni et al. Kidney Int 61: 305-16 2002
Fassiadis N et al. Semin Dial 20:455-7, 2007
O'Hare et al. Kidney Int 64: 681-89 2003

Pharmacological

Dialysis Access Consortium (DAC)

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

	Thrombosis	Suitability
Clopidigel	12.2%	61.8%
Placebo	19.5%	59.5%

Dember et al. JAMA 2008, 299: 2164-71.

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

Yerdel et al. Nephrol Dial Transplant 12: 1684-88, 1997
Malovrh et al. Nephrol Dial Transplant 13:125-9, 1998
Robbin et al. Radiology 225: 59-64, 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

	salvage rate	primary patency rate	multiple pathology
Beathard 2003	82%	75%	78%
Nassar 2006	83%	65%	73%
Clark 2006	88%	34%	42%
Falk 2006	74%	nana	
Song 2006	95%	28%	na
Miller 2009	96%	39%	na

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.
Miller et al. J Vasc Access 10: 183-91, 2009

Sheathless access
Staging procedures
Long balloon lengths(8-10 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 nonmaturingautogenous radial-cephalic fistulas for hemodialysis

Turmel-Rodrigues et al. Nephrol Dial Tranplant 24: 3782-88, 2009.

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%)
distal radial artery ligation

Assisted patency 12 mo 24 mo
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
- 6F sheaths

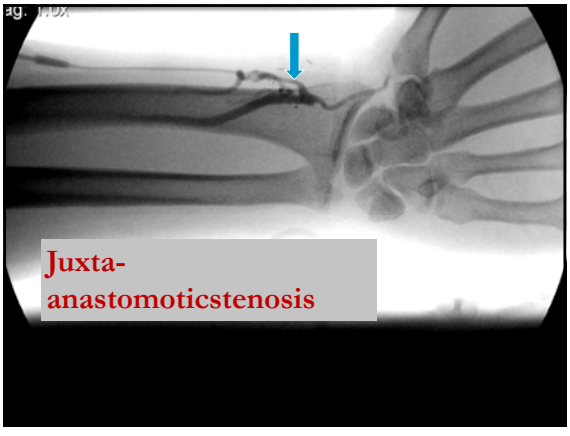
No anticoagulant
- frequent saline flushes

Tourniquet to decrease arterial pressure

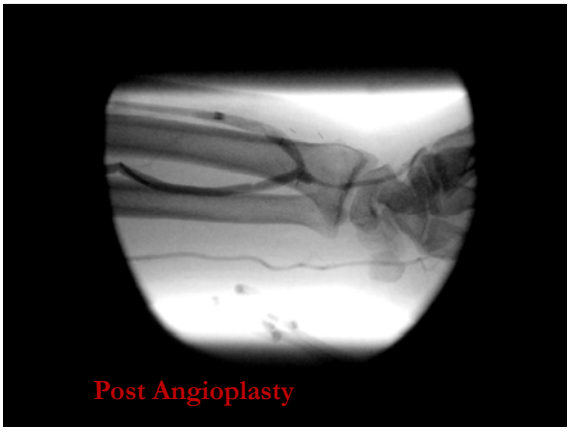
Highlights:

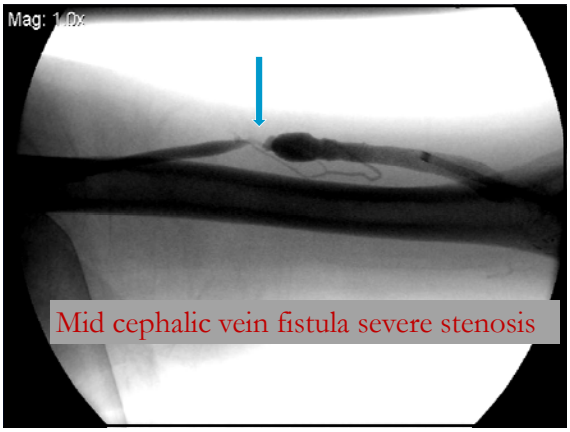
"All arterial stenoses dilated to 4mm at 25atm"
- cutting balloon PTA refractory lesions

Mean artery stenosis length 6.8 cm




Percutaneous Transluminal Angioplasty


Post Angioplasty


Mag: 1.0x
Mid cephalic vein fistula severe stenosis

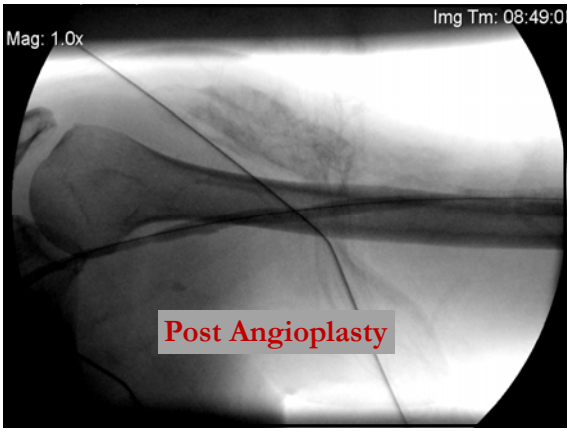
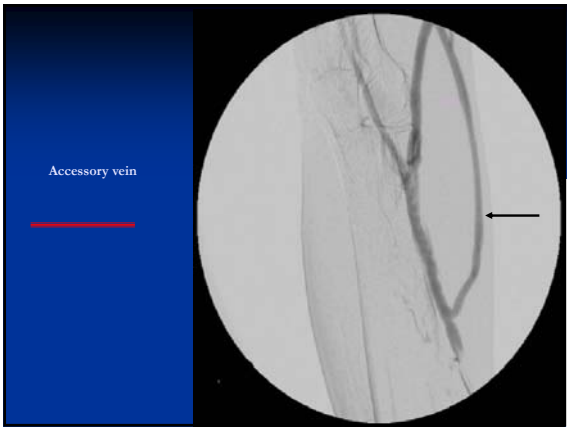
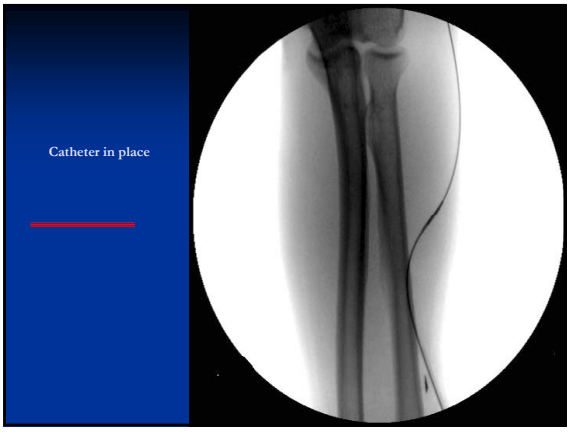
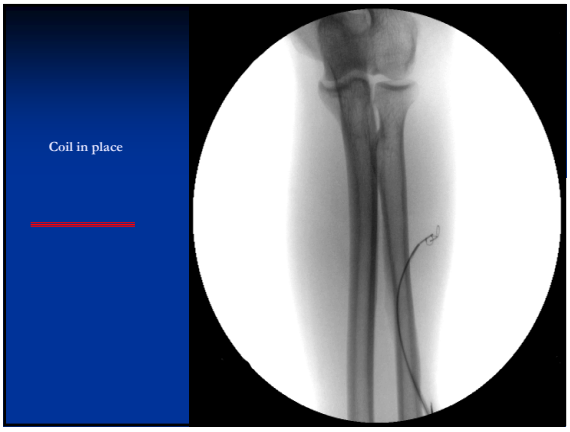

Mag: 1.0x
Post Angioplasty

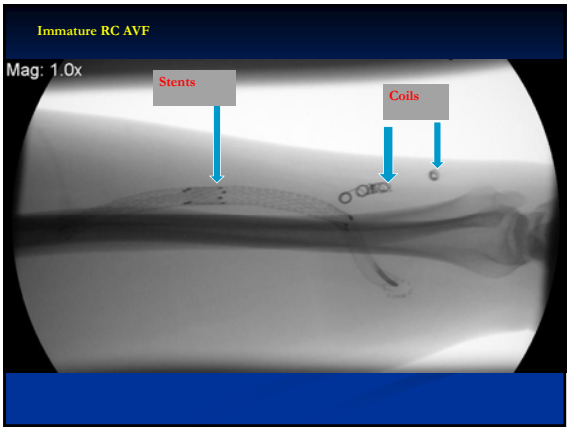

Figure 1. A sample of two vascular lesions that were encountered during salvage procedures on "failing to mature" arteriovenous fistulas (AVF)
A
B
C
D
Nassar, G. M. et al. Clin J Am Soc Nephrol 2006;1:275-280
Copyright ©2006 American Society of Nephrology
CJASN

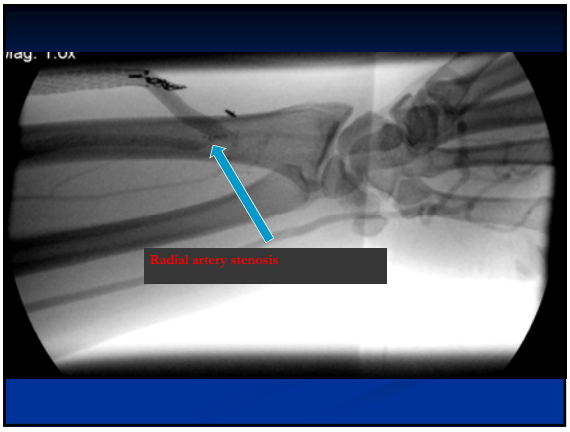

Accessory vein


Catheter in place

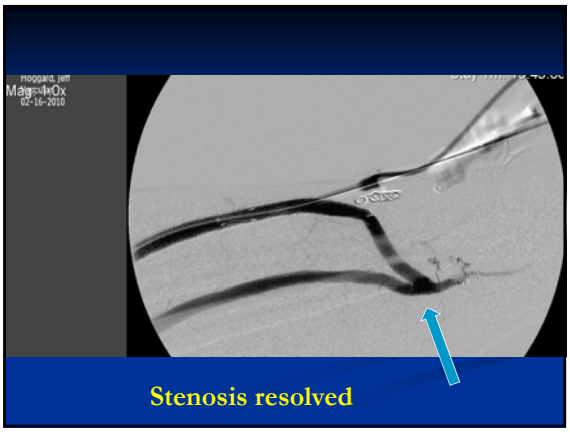

Coil in place

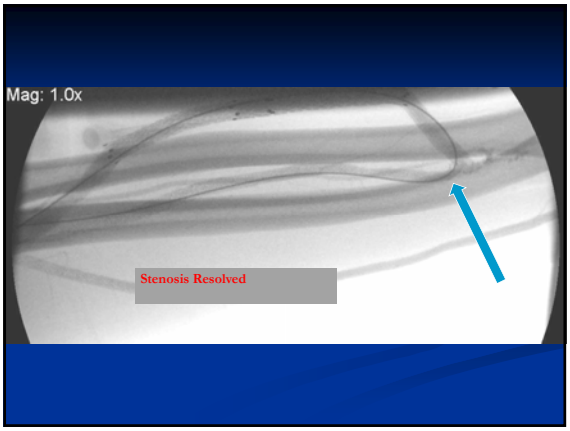

Final
Result


Immature RC AVF
Mag: 1.0x
Stents
Coils


Radial artery stenosis


Mag: 1.0x





Conclusion and Summary

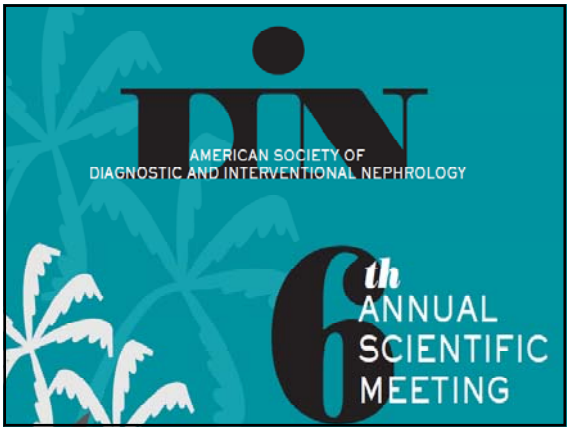
AVF: Primary Failure Rate 40%

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

Operative/Surgical:
- new drug/ molecule therapies(pancreatic elastase- induces vein dilatation by promoting breakdown of collagen)

Conclusion and Summary

Post-operatively:
- endovascular interventions when applied appropriately and judiciously can be very successful in converting the immature avf into a functional HD access



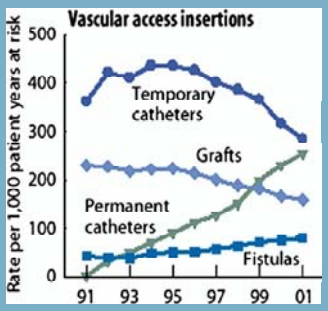
Fistula First:
Impact on AVF, AVG and Catheters
An Update

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'

Trends in Access Insertions: 1991-2001



Lacson et al. Am J Kidney Dis 50:379-395. © 2007

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

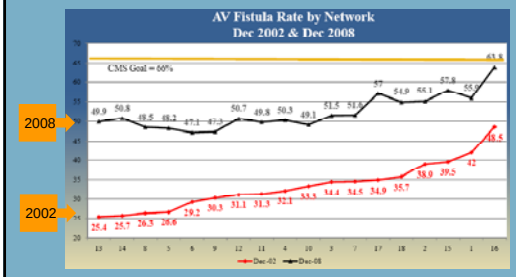
FF: Key Recommendations

- 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'*
- 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

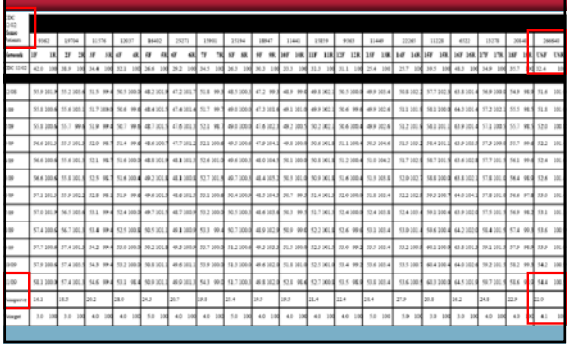
Fistula Rates By Network: 2002 and 2008



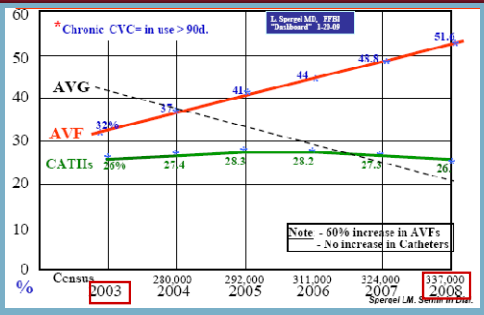
Network

Armistead N. Network/CMS annual meeting presentation 2009.

Prevalent AVF: Nov 2009 (FF Dashboard)



FF: Impact on AVG (2003-2008)



Spergel L Network/CMS annual meeting presentation 2009.

State of Access: August 2009 (FF Dashboard Summary)

August 2009	Type of Access	Prevalent	Incident
FFOD			
	AVF	187,708	9900
	AVG	72044	2429
	AVG+AVF	2010	2119
	Catheter <90 days	19851	36633
	Catheter >90 days	36223	369
	Catheter+AVF	25622	7847
	Catheter+AVG	6379	987
	Total	350,721	60,284

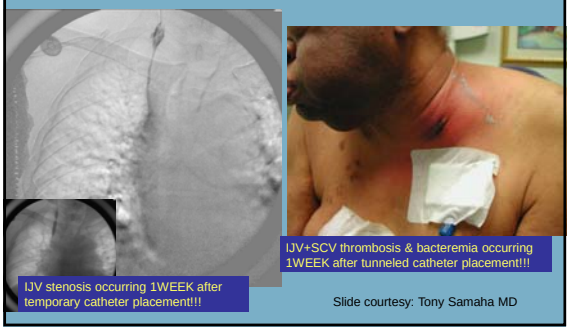
Incident Catheters: USRDS 2009 Report

- 2007 data showed that 81% of patients started dialysis with catheter
  - Attributed to multiple factors
    - late referral to nephrologists
    - late referral to surgeons
    - patient resistance
    - co-morbidities
    - poor access to care
  - Could preoccupation in trying to mature AVF have contributed to the rise in catheter rates?

Incident Accesses: 2008 (FF Dashboard) And Nephrology Care

Location	Access Type at Start[2]						Maturing[3]				Prior Nephrology Care[4]				
Network	% AVF	# AVF	% AVG	# AVG	% CVC	# CVC	% AVF Maturing	# AVF Maturing	% AVG Maturing	# AVG Maturing	% under Nephro-logist Care	# under Nephro-logist Care	% < 6 months	# < 6 months	% 6 - 12 months	# 6 - 12 months
US	13.7	13796	3.3	3309	81.8	82705	15.6	15779	2.0	2049	54.3	54886	28.7	11379	37.2	20415
1	20.7	652	3.5	117	75.7	2529	18.3	612	2.7	89	70.1	2345	5.0	118	41.6	976
2	16.1	1072	4.0	264	78.9	5246	21.6	1437	3.2	215	57.0	3793	14.2	537	43.0	1630
3	12.6	594	2.5	119	84.7	3989	21.5	1011	2.9	136	49.3	2320	4.5	105	47.5	1101
4	14.3	695	2.9	139	82.7	4011	13.1	638	1.4	67	58.0	2828	36.3	1026	26.7	755
5	12.7	725	4.3	244	82.8	4717	13.5	771	2.2	127	54.7	3116	23.5	731	38.9	1211
6	15.4	1268	4.7	384	79.8	6593	16.3	1350	2.4	197	60.2	4976	14.4	716	38.9	1935
7	10.5	693	2.3	149	87.0	5747	16.6	1099	1.5	101	49.8	3294	25.4	837	32.7	1078
8	13.6	748	5.1	277	81.0	4442	16.4	898	3.1	172	55.1	3024	29.9	903	32.3	976
9	12.5	991	2.9	232	78.1	6210	14.6	1158	1.5	121	52.9	4209	40.3	1695	26.0	1094
10	10.0	445	3.0	133	79.6	3528	11.3	500	1.2	52	44.1	1953	40.8	796	29.1	568
11	14.2	931	2.0	106	82.9	5427	12.9	844	1.5	98	58.4	3824	7.9	302	36.1	1382
12	13.5	498	2.2	81	84.2	3123	15.7	582	1.1	39	58.7	2177	17.6	384	34.2	745
13	11.0	477	2.6	111	86.3	3754	13.4	581	2.0	85	50.7	2205	10.5	231	45.0	992
14	11.4	963	3.6	306	84.9	7141	17.3	1455	3.1	265	51.5	4334	3.2	139	50.2	2174
15	14.6	677	1.9	88	83.4	3861	14.9	688	0.9	42	56.7	2625	21.4	561	35.0	918
16	23.0	615	2.5	68	74.5	1994	19.6	524	1.4	37	66.8	1789	10.0	179	32.5	582
17	17.5	831	3.5	166	78.8	3752	16.9	802	2.2	104	58.4	2777	38.7	1075	28.1	779
18	11.0	880	3.1	245	83.0	6621	10.4	829	1.3	102	41.3	3297	31.7	1044	46.1	1519

Tunneled Catheter: No TIME safety Central Vein Stenosis & Infection



IJV stenosis occurring 1WEEK after temporary catheter placement!!!

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

Slide courtesy: Tony Samaha MD

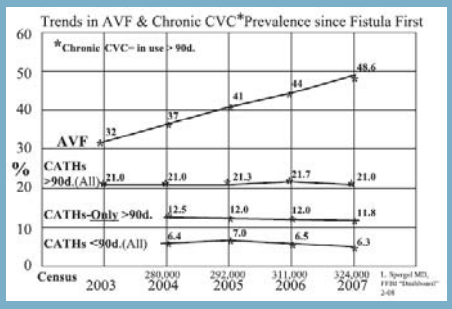
FF: Impact on Catheters

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

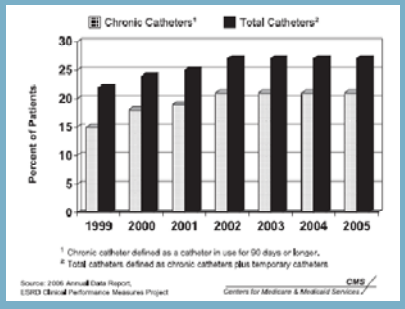
Seminars in Dialysis
Vol 21, No 6 (November–December)
2008 pp. 550–552

Trends in AVF and CVC Prevalence Since FF 2003-2007



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

Catheter Rates Around FFBI Inception



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

Continuing Impact of FF On Access Type

Changes in Prevalent AV Access 2007-2009			
AV acess	Jan 2007 (%)	Mar 2009 (%)	Diff (95% CI)
AVF	45.2	52	6.8 (6.2, 7.3)
Cath > 90 days	12	10.9	-1.1 (-1.4, -0.7)
Cath < 90 days	6.9	5.9	-0.9 (-1.2, -0.7)
AVF & cath	7.8	7.5	-0.3 (-0.6, -0.1)
AVG & Cath	2.2	1.9	-0.3 (-0.4, -0.2)

Spergel, LM et al. J Am Soc Nephrol 2009;20:683A

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

American Journal of Kidney Diseases, Vol 50, No 3 (September), 2007: pp 379-395

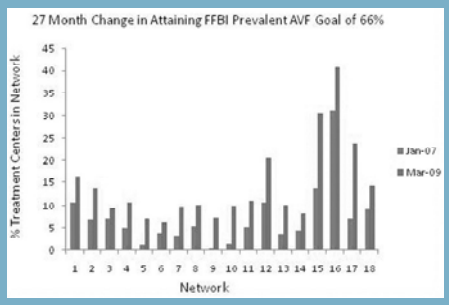
Barriers to Catheter Reduction

- 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?



Spergel, LM et al. J Am Soc Nephrol 2009;20:477A

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

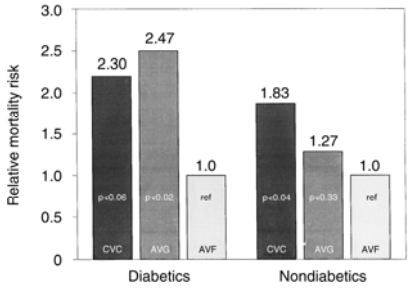
Monnie Wasse, MD, MPH
Emory University
Renal Division & Interventional Nephrology

- Financial disclosure: None

Vascular Access & Mortality

- Cause of death
  - infection
  - cardiovascular
  - all-cause
- Other factors to consider

Infection-related death by vascular access type



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

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

Catheters are associated with increased infection-related hospitalization & death

Cardiovascular-related death by vascular access type: *Incident patients*

At Dialysis initiation	90 days after dialysis start
AVF =CVC	AVF vs CVC:HR=0.69
AVG =CVC	AVG = CVC
Lack of association likely due to high rate of death within first 90 days from other causes	Possibly related to reduction in systemic inflammation

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

Cardiovascular-related death by vascular access type: *Prevalent patients*

Non-diabetic	Diabetic
CVC vs AVF:RR= 1.38	CVC vs AVF:RR=1.85
AVG =AVF	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	Diabetic
CVC vs. AVF:OR=1.7	CVC vs AVF:OR=1.54
AVG =AVF	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=AVG

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

Vascular access & all-cause mortality

- CVC vs AVF: RR 1.32
- AVG vs AVF: RR 1.15 (P<.001)

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

Vascular access & all-cause mortality

- CVC patients have increased risk of infectious, cardiovascular and all-cause death compared with AVF and AVG users
- Change from CVC to permanent access reduces all-cause mortality
- AVG vs AVF patients?
  - Diabetics with AVG have greater all-cause mortality than AVF patients
  - No difference in patients > 67 yo

Additional factors to consider: QOL

- Quality of life
  - Random sample 1563 incident ESRD patients[1]
  - 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*

[1]Wasse et al, CJASN, 2007

Additional factors to consider: cost

- 2010 USRDS Annual Data Report
  - per person per year total costs
    - CVC $79,364
    - AVG $72,729
    - 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