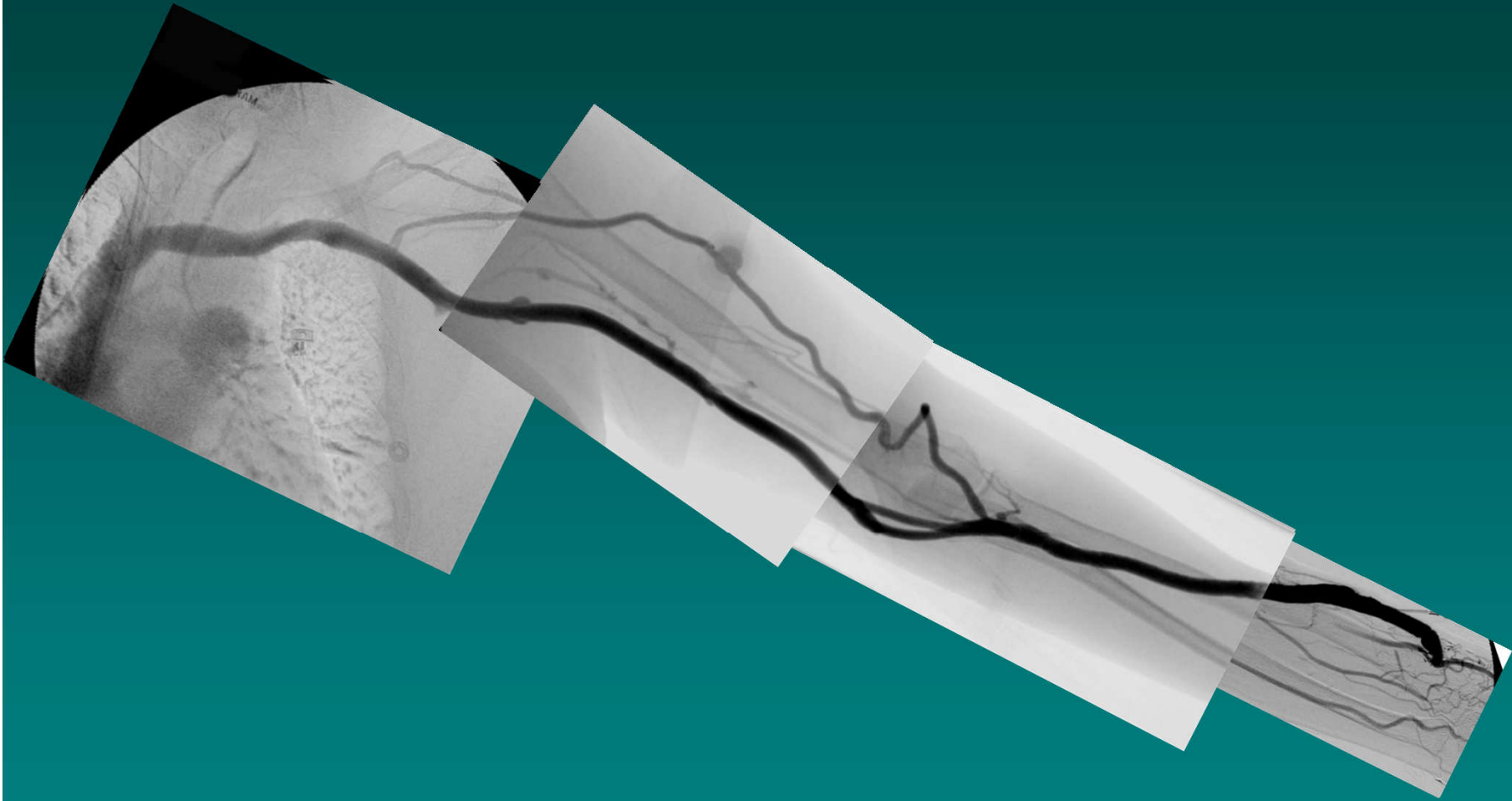


Management of the Immature Fistula

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Nephrology Associates, P.A.
Newark, Delaware



“Mature” Fistula?



What is a “Mature” AVF?

- Vein able to be safely and reliably accessed 3 times per week with two 17, 16, or 15 ga. dialysis needles
 - Diameter: >6 mm
 - Depth: <6 mm
 - Length: >6 cm
 - Straight
 - Vessel Wall quality
 - “Arterialization”
- Fistula flow sufficient to deliver necessary rate of blood to the dialysis circuit
 - >150% of desired pump speed: e.g. 400 ml/min
 - >600 ml/min
- Dependent upon
 - Cardiac output
 - Blood pressure
 - Artery size & quality

Fistula Maturation & Adequacy of Hemodialysis

- Adequacy as assessed by urea clearance
- Kt/V : Fraction of total body distribution volume cleared during dialysis session equals
 - K_{urea} = Dialyzer urea clearance
 - T_d = Dialysis time
 - V_{urea} = Urea distribution volume
 - Approximates total body water
- Target $Kt/V > 1.4$

KT/V & Adequacy: One Size Doesn't Fit All



KT/V & Adequacy: One Size Doesn't Fit All

100 kg patient: $Kt/V=1.4$

- Urea volume = 60,000 ml
- Time = 240 minutes
- $K_{\text{urea}} = 350$ ml/min

Less efficient dialyzer urea clearance at higher blood flow rates

- Blood flow to dialyzer
 - 450-550 ml/min
 - ≥ 15 gauge needles

Requires access blood flow 50% greater than dialyzer pump speed

- Access flow >750 ml/min

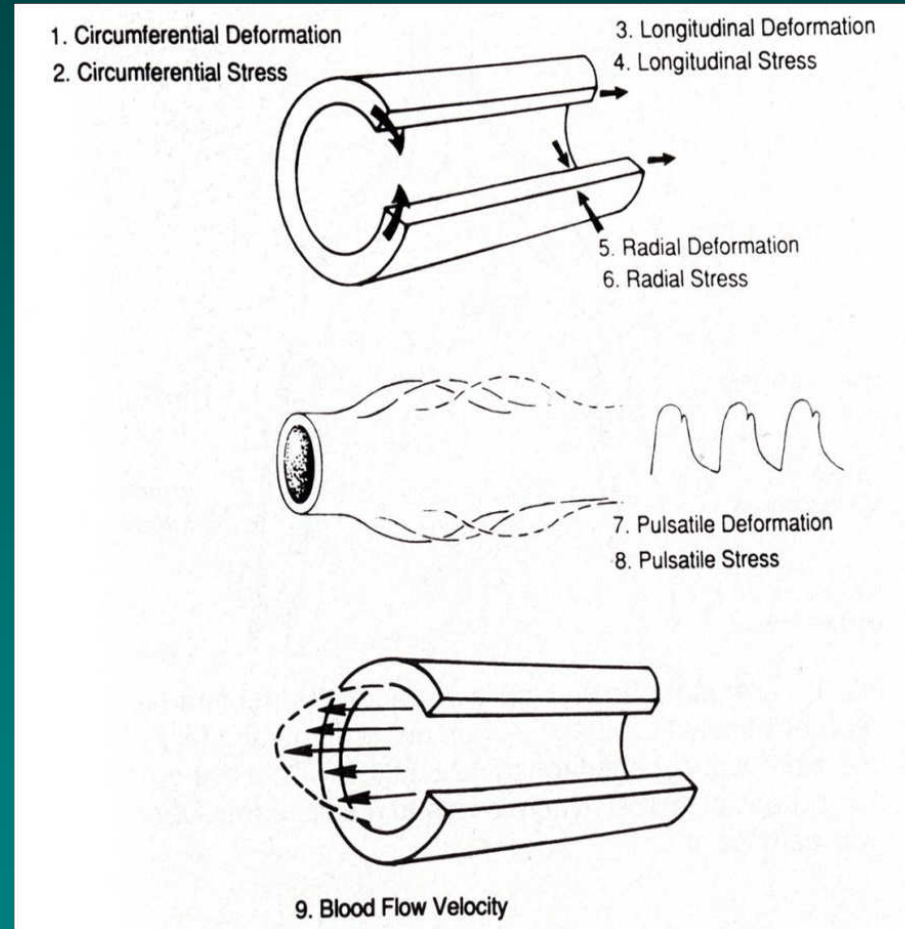
50 kg patient: $Kt/V=1.4$

- Urea volume = 30,000 ml
- Time = 240 minutes
- $K_{\text{urea}} = 175$ ml/min

- Blood flow to dialyzer
 - 200-250 ml/min
 - 17 gauge needles

- Access flow 300 ml/min

AVF Maturation: Hemodynamic Factors



Dobrin et al: Surgery 105:393-400, 1989

Courtesy of Arif Asif, M.D.

AVF Maturation: Humoral Factors

- *Adaptive Remodeling*
 - Reorganization of cellular and extracellular components
- *Role of Endothelial Cells:*
 - De-endothelialized vessels fail to increase diameter in response to increased blood flow (1, 2)
- *Shear stress:*
 - Apical surface of the endothelial cell
 - Transduction of hemodynamic forces
 - Subendothelial compartment
 - Nitric oxide, prostacyclin
 - Activation of a variety of transcription factors and matrix metalloproteinases (3)
 - *NO and MMPs:* Appear to play a major role.

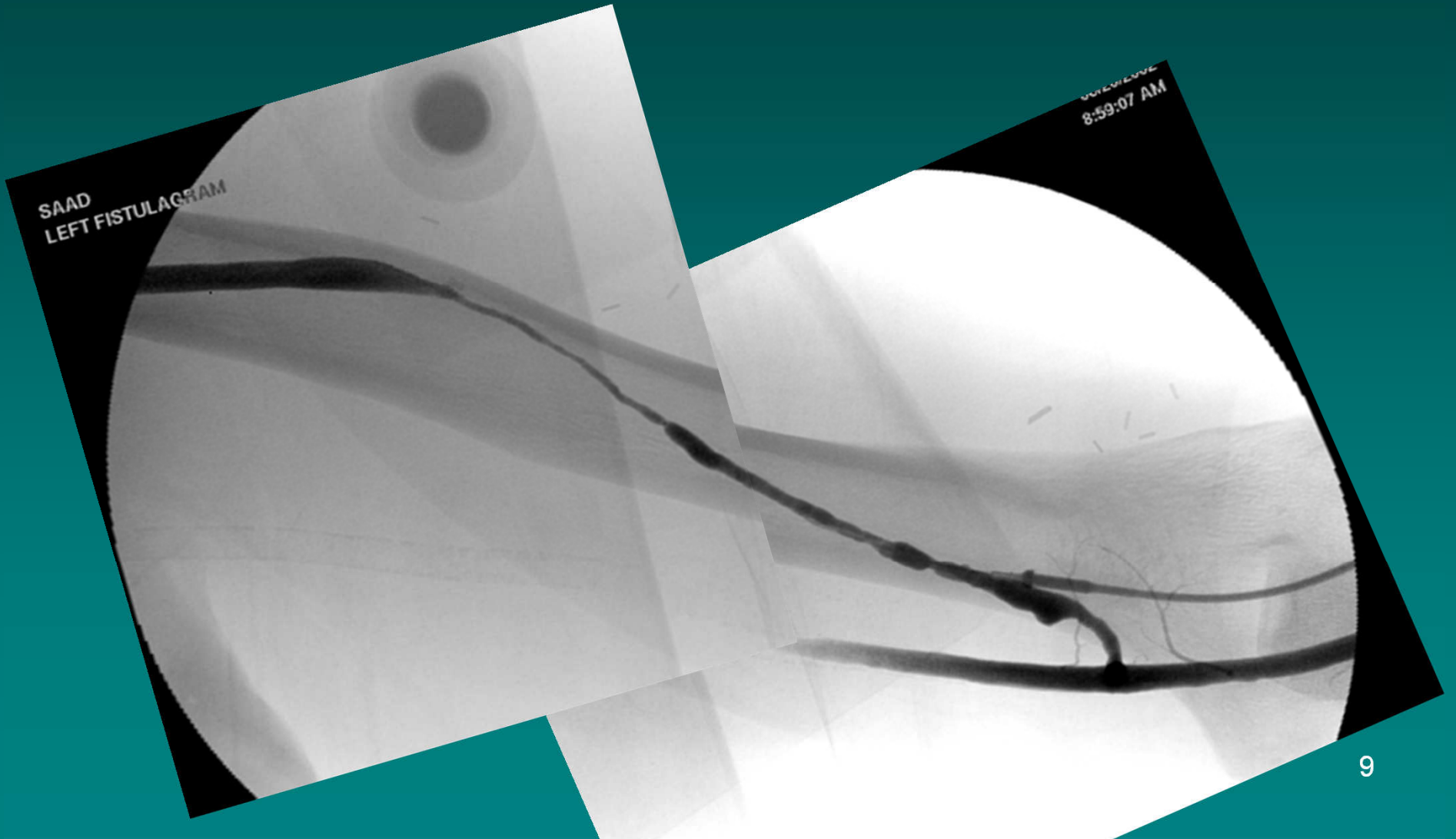
1- Tohda et al.: *Arterioscler Thromb* 12:519-528, 1992.

2- Langille BL, O'Donnell F: *Science* 231:405-407, 1986

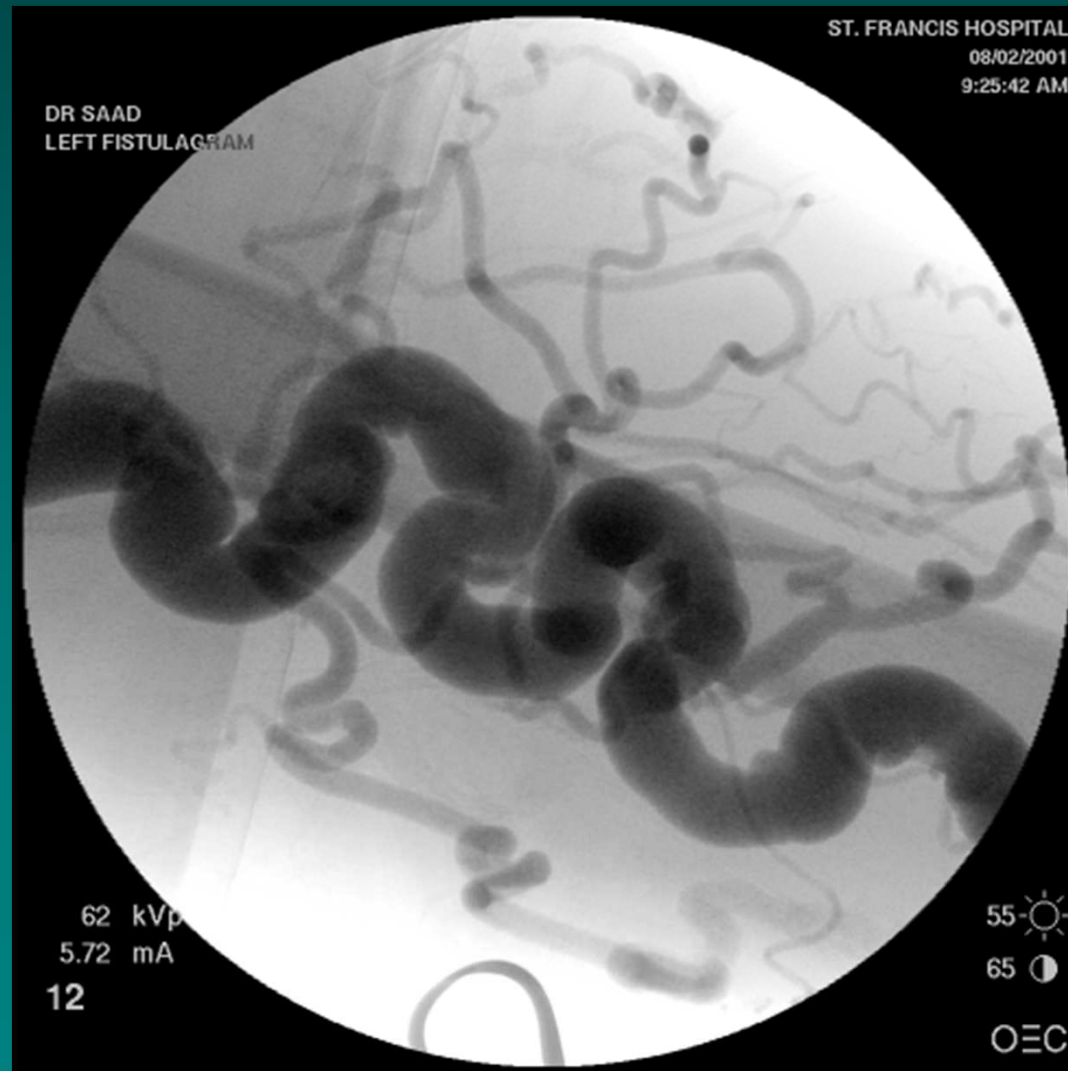
3- Ballermann et al: *Kidney Int* 67:S100-S108, 1998

Courtesy of Arif Asif, M.D.

LUA Transposed Cephalic AVF: Delayed Maturation

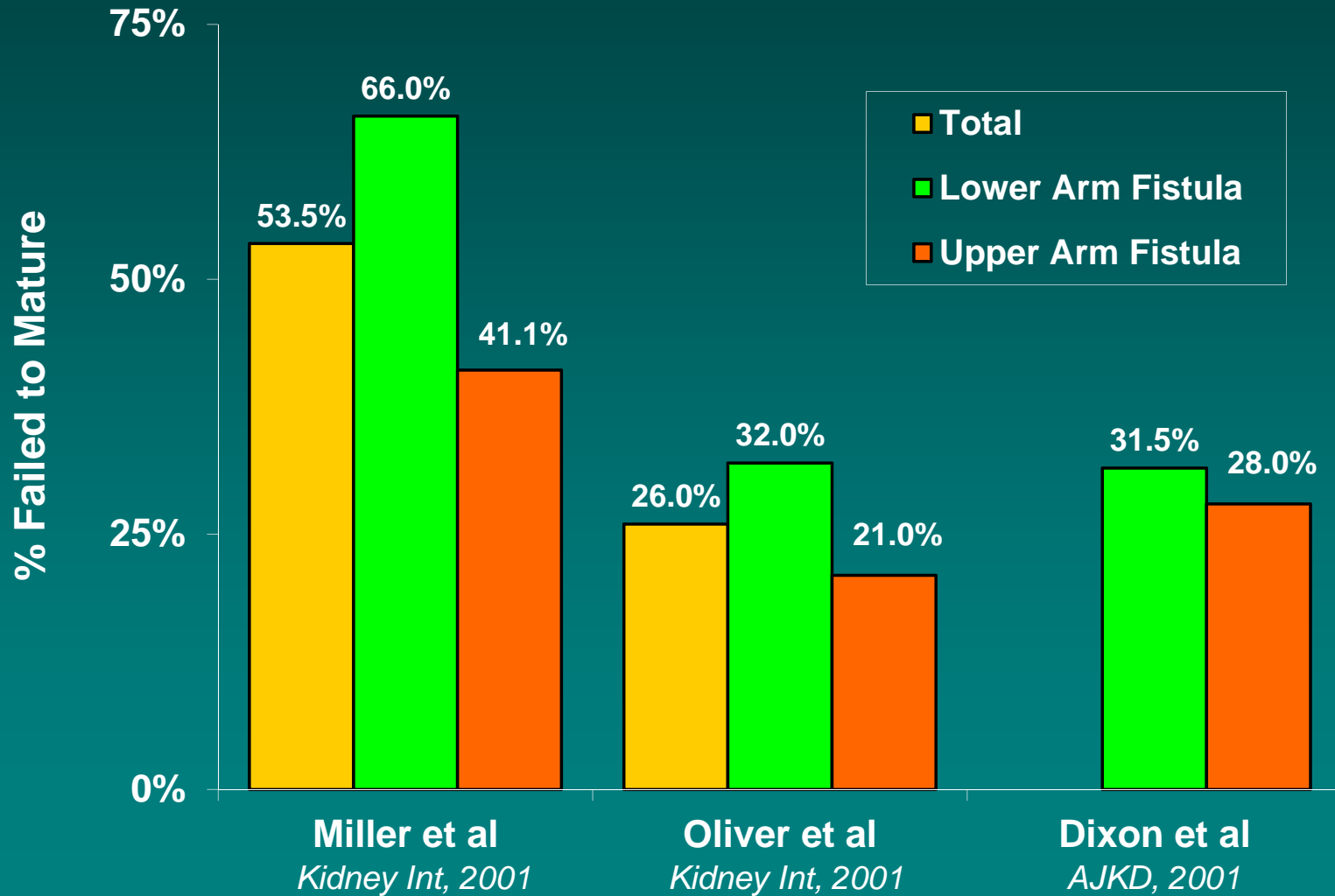


Native Arteriovenous Fistula: Patterns of Maturation





Some Fistulas Fail to Mature



Effect of clopidigrel (Plavix™) on Early Failure of AV Fistulae

Table 3. Fistula Suitability Failure

	No. (%) of Patients		Relative Risk (95% Confidence Interval) ^b
	Clopidogrel (n = 385) ^a	Placebo (n = 373) ^a	
Suitability failure (all patients)	238 (61.8)	222 (59.5)	1.05 (0.94-1.17) ^c
By location			
Forearm fistula	144 (66.9)	137 (64.0)	1.05 (0.92-1.20)
Upper arm fistula	94 (55.3)	85 (53.4)	1.05 (0.87-1.27)
By failure reason			
Fistula abandoned with no expectation of future use	115 (29.9)	134 (35.9)	0.85 (0.69-1.03)
Fistula not yet in use despite treatment with dialysis	57 (14.8)	47 (12.6)	1.17 (0.83-1.66)
Fistula in use during ascertainment period but failed to meet suitability criteria	66 (17.1)	41 (11.0)	1.56 (1.08-2.24)

^aFifty-six of the 441 patients randomized to clopidogrel and 63 of the 436 patients randomized to placebo were not included because suitability was not ascertained (Figure).

^bRelative risks were stratified for fistula location and center.

^cP = .40.

Physical Training: Myth of the Red Rubber Ball

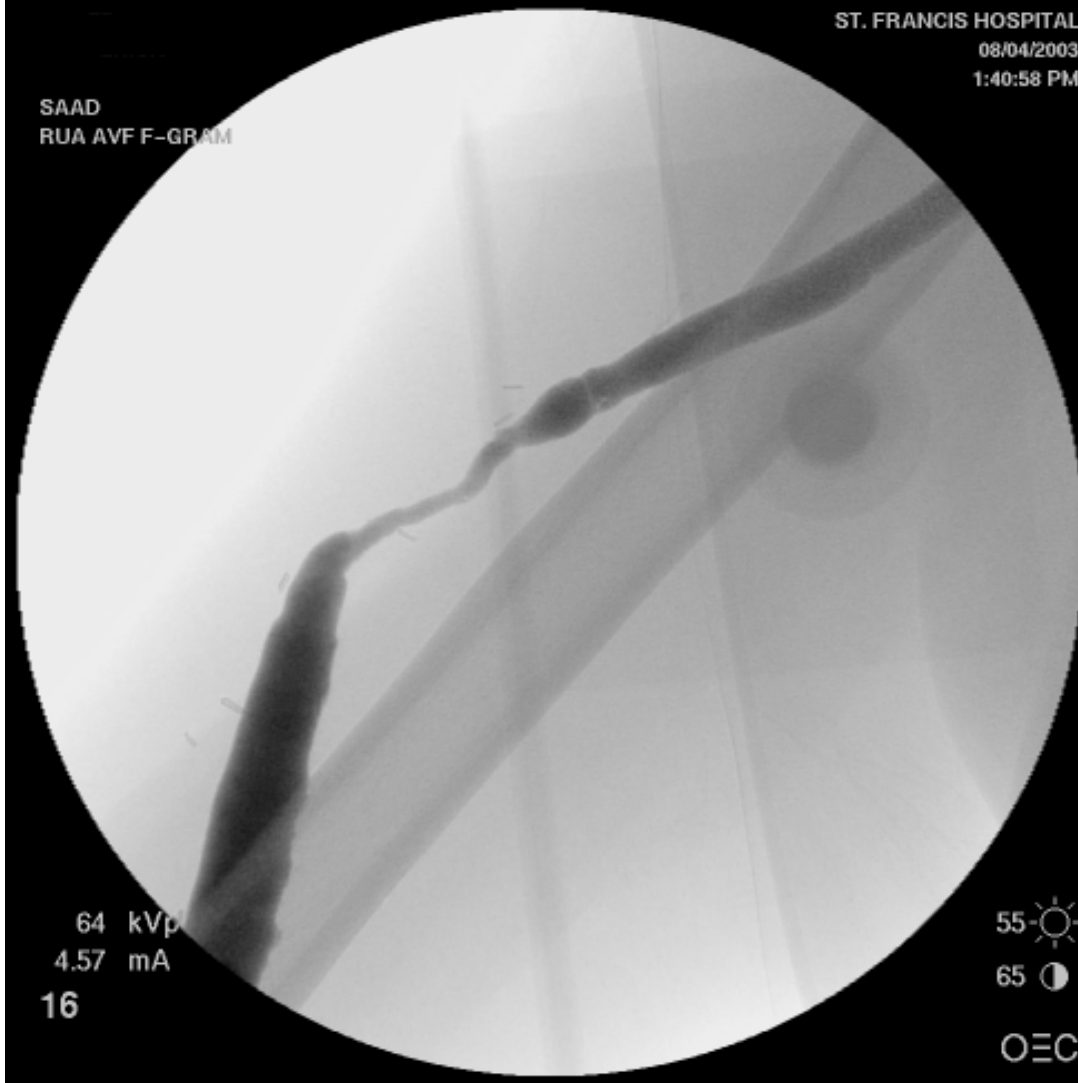


- Immediate effects
- Oder (ASAIO 2003)
 - 23 patients
 - AVF 2.8 months old
 - 5 minutes hand exercise
 - Red rubber ball
 - Fistula diameter increased 9.3%
 - 20/23 patients
- Long-term effects
- Rus (Blood Purif 2003)
 - 14 ESRD patients without AVF
 - 8 weeks Handgrip training
 - Increased
 - Radial artery diameter
 - Maximum vein diameter

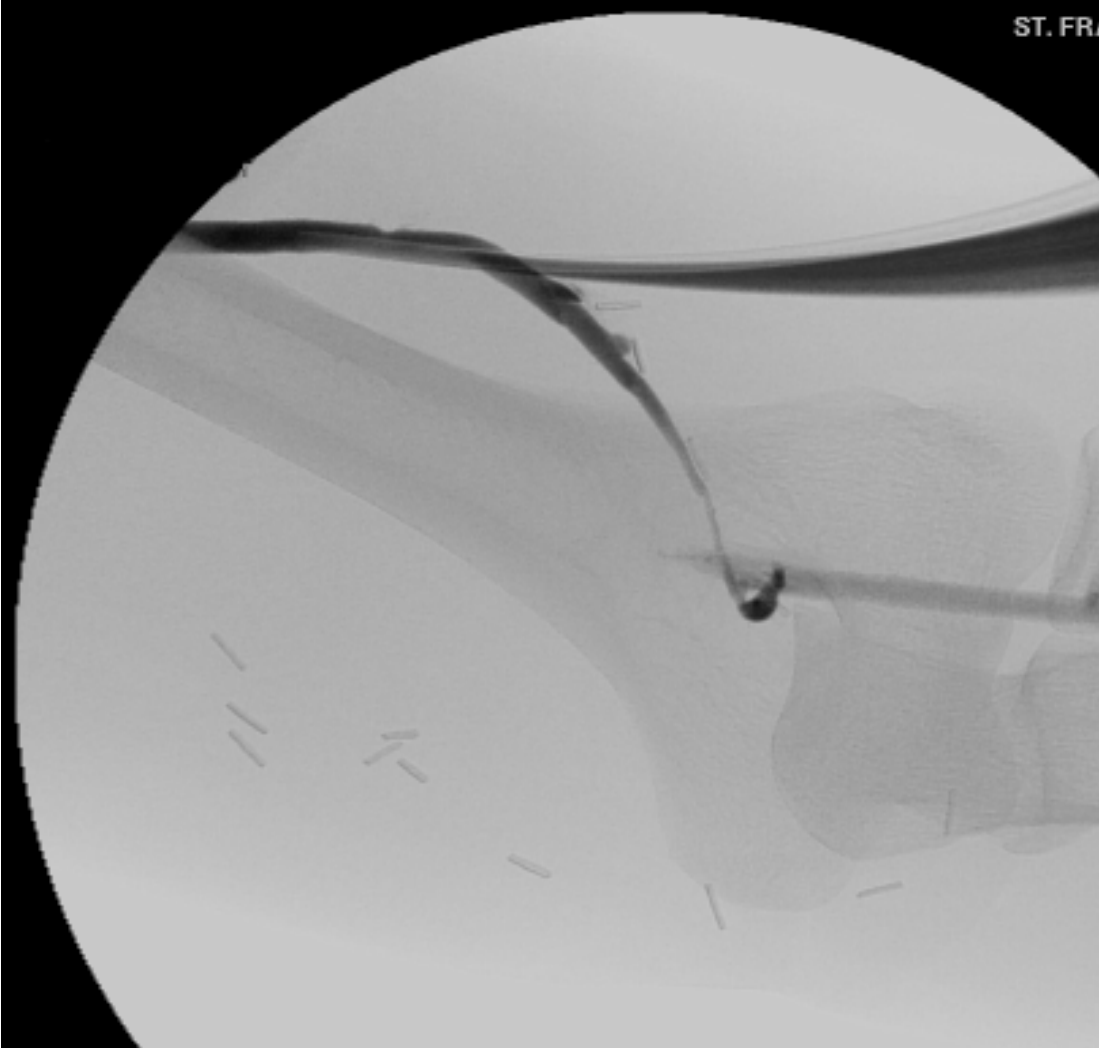
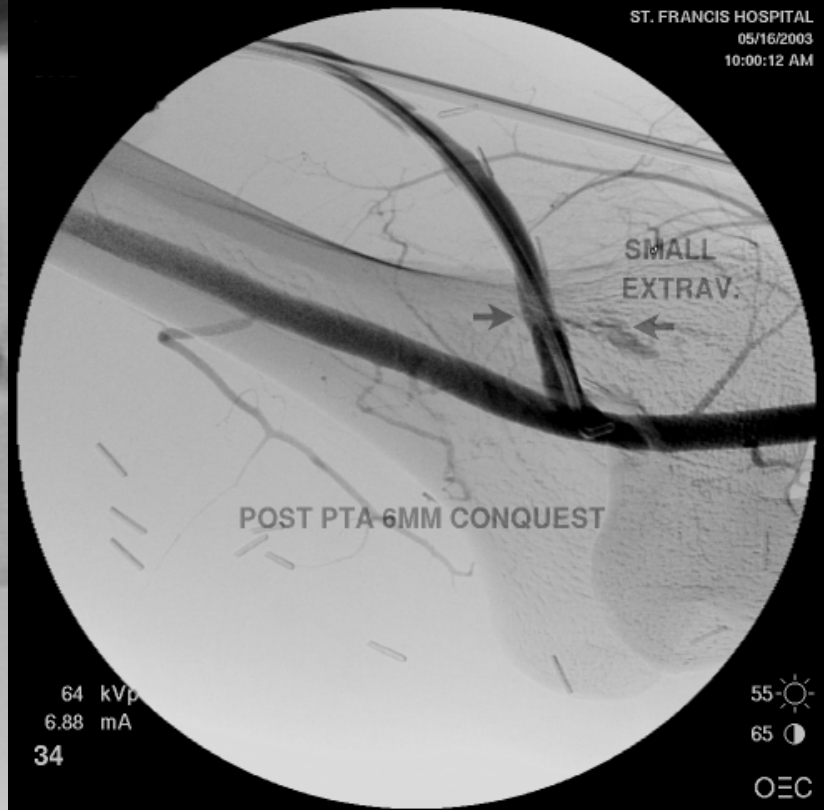
Failure to Mature

- Focal venous stenosis
 - Pre-existing vein damage or disease
 - Surgery-related vein damage
 - Juxta-anastomotic or “swing-point” stenosis
- Diffuse vein stenosis
 - Intrinsic vessel disease
- Accessory or “competing” veins
- Hemodynamic factors
 - Arterial calcification
 - Poor cardiac output and/or blood pressure
- ~~Failure to squeeze the ball~~

“Swing-point” Stenosis



Juxta-Anastomotic Stenosis

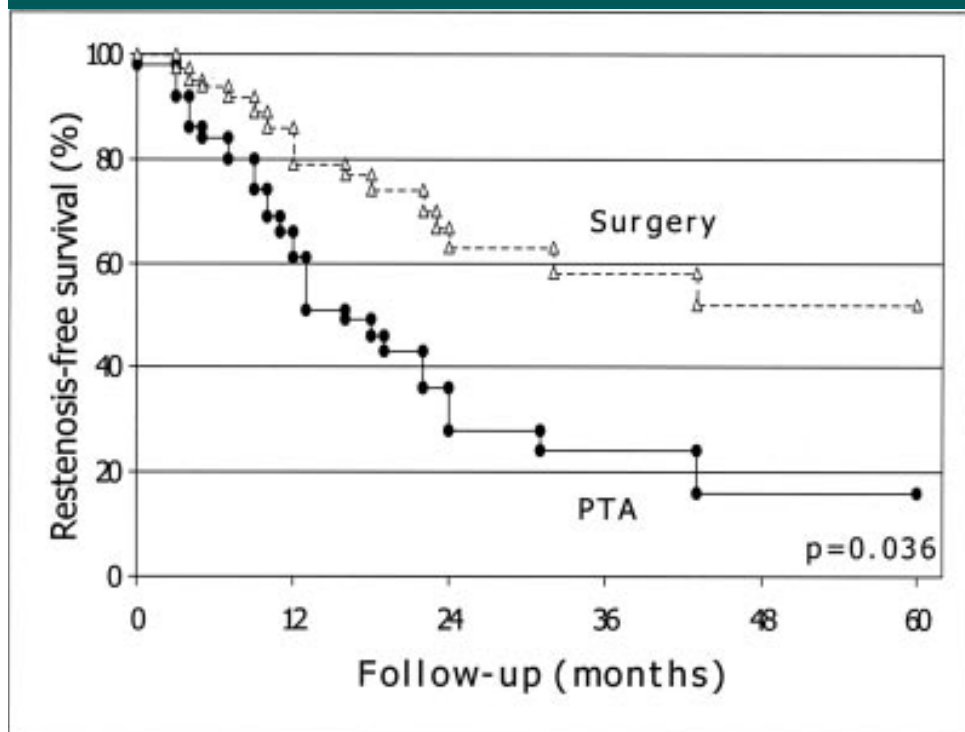


Endovascular *versus* Surgical Preemptive Repair of Forearm Arteriovenous Fistula Juxta-Anastomotic Stenosis: Analysis of Data Collected Prospectively from 1999 to 2004

Nicola Tessitore,* Giancarlo Mansueto,[†] Giovanni Lipari,[‡] Valeria Bedogna,* Stefano Tardivo,[§] Elda Baggio,[‡] Daniela Cenzi,[‡] Giovanni Carbognin,[‡] Albino Poli,[§] and Antonio Lupo*

*Divisione di Nefrologia, [†]Dipartimento di Radiologia, [‡]Dipartimento di Scienze Chirurgiche, and [§]Dipartimento di Medicina e Sanità Pubblica, Università di Verona, Verona, Italy

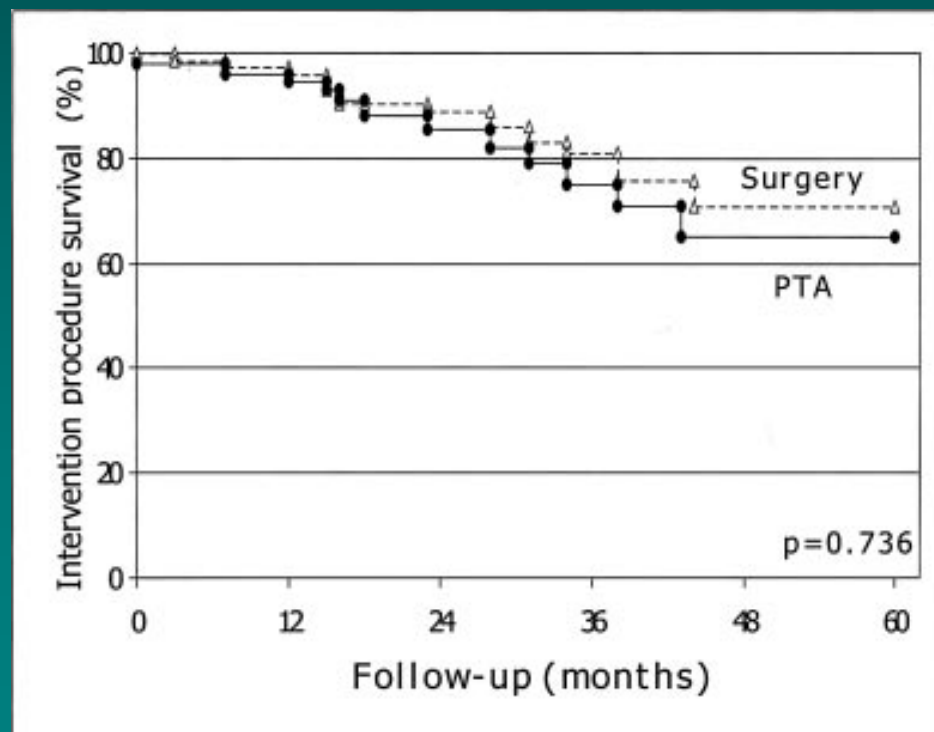
Primary Patency



AVFs at risk:

	0	12	24	36	48
Surgery	21	19	8	5	4
PTA	43	19	7	5	2

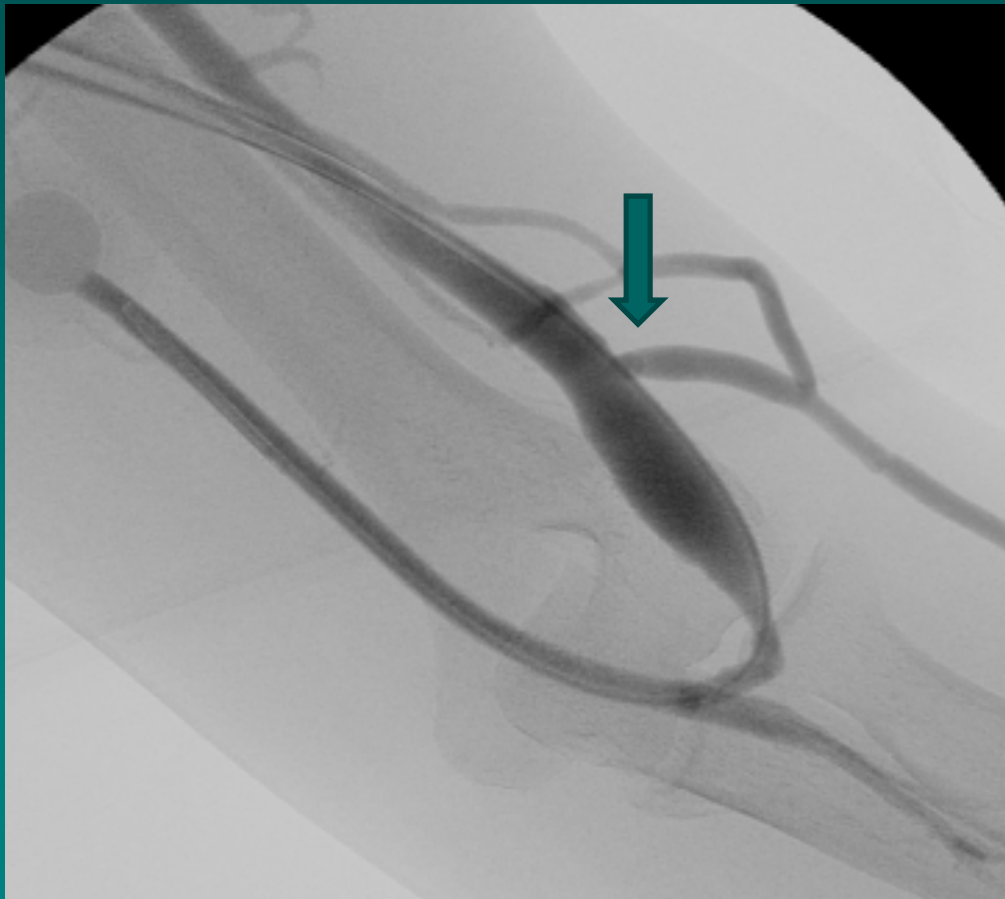
Assisted Primary Patency



AVFs at risk:

	0	12	24	36	48
Surgery	21	20	11	8	5
PTA	43	32	19	13	6

AVF Maturation: Competing or Accessory Vein Ligation



Balloon Assisted AVF Maturation: “Silk purse from sows ear?”



“Balloon Maturation” Definition

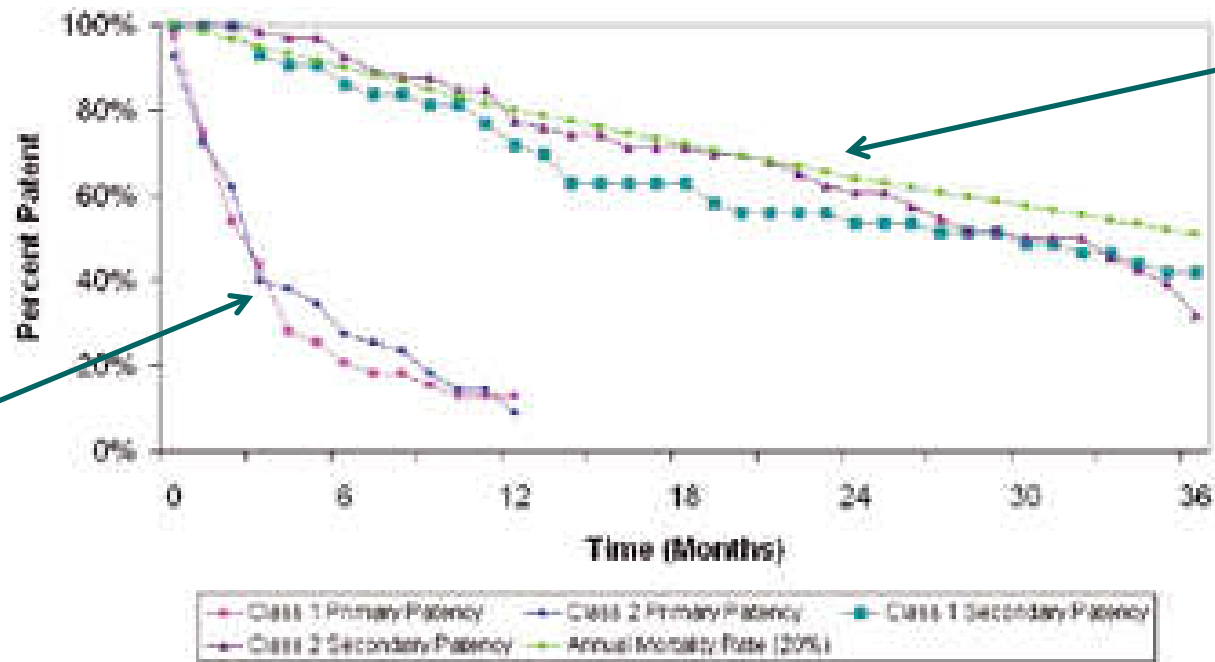
- Use of balloon angioplasty to achieve long-segment vein dilation that has not occurred spontaneously
 - Involves the intended fistula puncture zone
 - Sequentially larger balloons
- Distinct from treatment of focal stenosis
 - Juxta-anastomotic or swing-point
- Limited data

Staged Balloon-Assisted Aggressive Maturation (BAM)

- 122 patients retrospective
 - Class I
 - Large (6-8 mm) vein
 - > 6 mm deep
 - Class II
 - Small (2-5 mm) vein
- Sequential dilation
 - Angioplasty at 2-4 week intervals
 - Start with at least 6-7 mm diameter balloon
 - Successively larger balloons :10-12 mm (max 16 mm)
 - Long length balloons for long segment lesions
 - Repeated until fistula usable
 - Successful maturation: 118/122 (96.7%)

Staged Balloon Assisted Aggressive Maturation Protocol

Primary and Secondary Patencies of Class 1 and Class 2 Fistulae



Class I & II
Primary
Patency

Secondary
Patencies

Interventions to Improve Fistula Maturation Rates

- Meta-analysis
 - 12 Reports, 745 patients
 - Variety of surgical and percutaneous methods
 - Angioplasty, stent, thrombectomy
 - Branch vein ligation
 - Surgical revisions
 - 86% success in achieving functional fistula
 - At 1 year
 - Primary patency 51%
 - Secondary patency 76%

Table IV. Efficacy of early nonmaturation treatment

First author	Year	AVF age, mon	Detected lesions					Techniques used					Success %	1Y PP ^a %	1Y SP ^b %
		Mean (range)	AI	JAn	VO	CV	AccV	PTA	AVE	AVL	Surg	Rev			
Turmel-Rodrigues ¹⁴	2001	2.5 (1.0-6.5)	4	38	27	0	0	...	...	...	...	...	97	39	79
Song ¹⁵	2006	2.7 (1.0-13)	0	18	4	0	0	...	...	...	...	...	96	28	85
Falk ¹⁶	2006	2.0 (0.3-8.5)	16	32	33	2	21	83	0	21	9	0	74	...	...
Shin ¹⁷	2005	1.5 (1.3-3.5)	1	13	5	1	14	19	0	0	0	0	74	61	82
Nassar ¹⁸	2005	4.6 (2-24)	62	76	95	10	35	...	...	...	...	...	83	62	95
Clark ¹⁹	2007	3.5 (0.7-14)	6	37	44	2	4	85	1	3	0	0	88	34	72
Beathard ²⁰	2003	4.7	42	15	20	9	46	110	34	12	0	0	92	68	...
Faiyaz ²²	2002	4.0 (1.7-7.5)	...	...	...	...	...	...	...	...	...	...	88	...	...
Asif ²³	2006	...	...	...	...	...	...	69	0	0	0	0	93	46	94
McLafferty ²⁴	2007	...	...	...	...	...	...	23	0	2	1	12	84	...	...
Beathard ²¹	1999	5.0 (1-13.9)	0	17	4	0	21	21	0	52	5	0	83	...	75
Singh ²⁵	2007	...	...	...	...	...	44	...	...	...	...	...	78	...	...
Sum			131	246	232	24	141	410	35	90	15	12			
Percentage, %			17	32	30	3	18	73	6	16	3	2			
Weighted average		3.2											86	51	76

..., Signifies that data were not clearly reported; AI, arterial inflow stenosis, located in the radial or brachial artery up until the start of the anastomosis; CV, central venous stenosis, located in the subclavian vein, innominate vein, or superior vena cava; AccV, accessory veins; AVE, accessory vein embolization; AVF, arteriovenous fistula; AVL, accessory vein ligation, including percutaneous ligation and ligation through incision; JAn, juxta-anastomosis stenosis, located in the initial 5 cm (2 inches) of the AVF starting just proximal of the anastomosis; PTA, percutaneous transluminal angioplasty, including balloon dilation, cutting balloon dilation, stenting, and endovascular thrombus aspiration techniques; Rev, revision surgery, including all techniques with which a new anastomosis was created; Surg, nonrevision surgery, including all surgical procedures where the original AVF was preserved (eg mainstream banding, superficialization, and thrombectomy); VO, venous outflow stenosis, located >5 cm proximal of the anastomosis up until the distal edge of the subclavian vein.

^a1Y PP: 1-year primary patency rate.
^b1Y SP: 1-year secondary patency rate.

Risk Equation Determining Unsuccessful Cannulation Events and Failure to Maturation in Arteriovenous Fistulas (REDUCE FTM I)

Charmaine E. Lok,^{*} Michael Allon,[†] Louise Moist,[‡] Matthew J. Oliver,[§] Hemal Shah,^{*} and Deborah Zimmerman^{||}

J Am Soc Nephrol 17: 3204–3212, 2006. doi: 10.1681/ASN.2006030190

- Risk factors for FTM in 422 patients receiving first AVF
- Risk Equation
 - Age ≥ 65 (OR: 2.23)
 - Peripheral Vascular Disease (OR: 2.97)
 - Coronary Artery Disease (OR: 2.83)
 - White Race (OR: 0.43)
- Scoring System
 - Base score “3”
 - Add score for factors
- Values
 - +2
 - +3
 - +2.5
 - 3

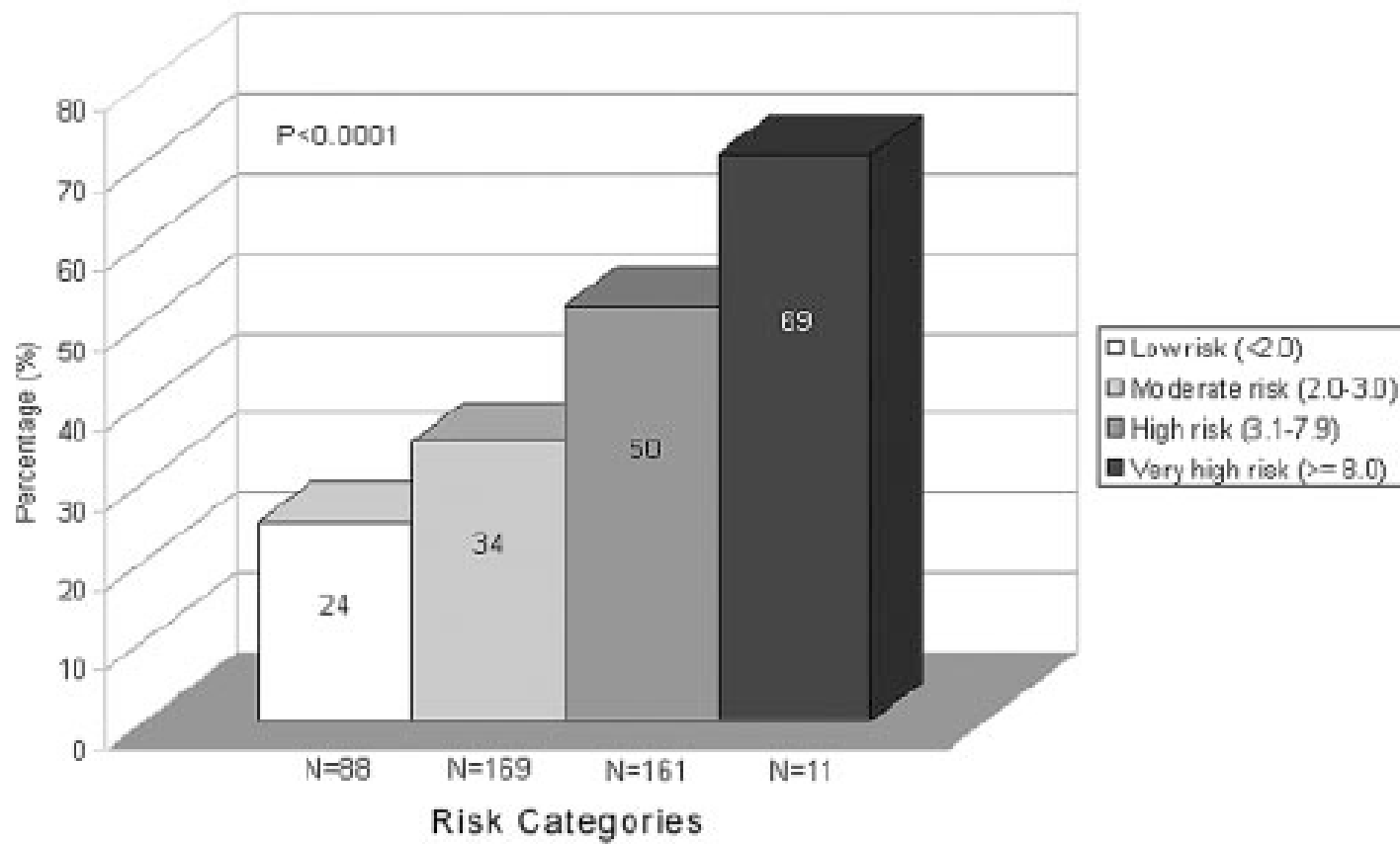
* Factors NOT correlated with FTM: Diabetes, obesity, gender, smoking

Scoring System

- Total Score 0 to 10.5
- Risk for Failure to Mature validated in prospective in group of 445 patients receiving first AV Fistula

<u>Score</u>	<u>Risk</u>	<u>FTM</u>	<u>Suggested Strategy</u>
≤ 2	Low	24%	PE & Routine mapping
2-3	Moderate	34%	Add venography
3.1-7.9	High	50%	Intense follow-up
≥ 8	Very High	69%	Consider graft

Risk of Fistula Failure to Mature



Fistula Maturation Protocol

Fistula Creation
 Side: Right Left
 Site/Type: _____
 Surgeon: _____
 Date: _____

Examine at 4 weeks
 Date: _____

1. Is fistula adequate size for cannulation (>6 mm)?
2. Is fistula superficial (<6 mm deep)
3. Does fistula have a good continuous "thrill" & bruit without excessively pulsatile quality?

Refer to Interventionalist or Surgeon for evaluation and possible ultrasound examination or fistulogram.

Potential problems include:

1. Inadequate inflow
2. Venous outflow stenosis
3. "Deep" fistula requiring transposition.
4. Accessory veins limiting flow

Attempt Needle Cannulation at 8 weeks
 Date: _____

1. Begin single 17 gauge cannulation
2. Advance to 16 gauge and then 2 needles as able
3. Measure access flow after successful 2 needle cannulation (if available)

Cannulation Protocol available At www.fistulafirst.org

Re-examine 4 weeks after intervention, or per recommendations of interventionalist.
 Date: _____
 Attempt fistula cannulation

Two weeks of continuous successful fistula cannulation?
 Date: _____

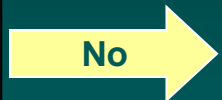
Refer to Interventionalist or Surgeon for evaluation

After evaluation and/or intervention, attempt cannulation protocol.
 If still not successful, patient should be referred back for re-evaluation every four weeks. Log dates here for interventional evaluation.

Date _____
 Date _____
 Date _____
 Date _____

Schedule catheter removal

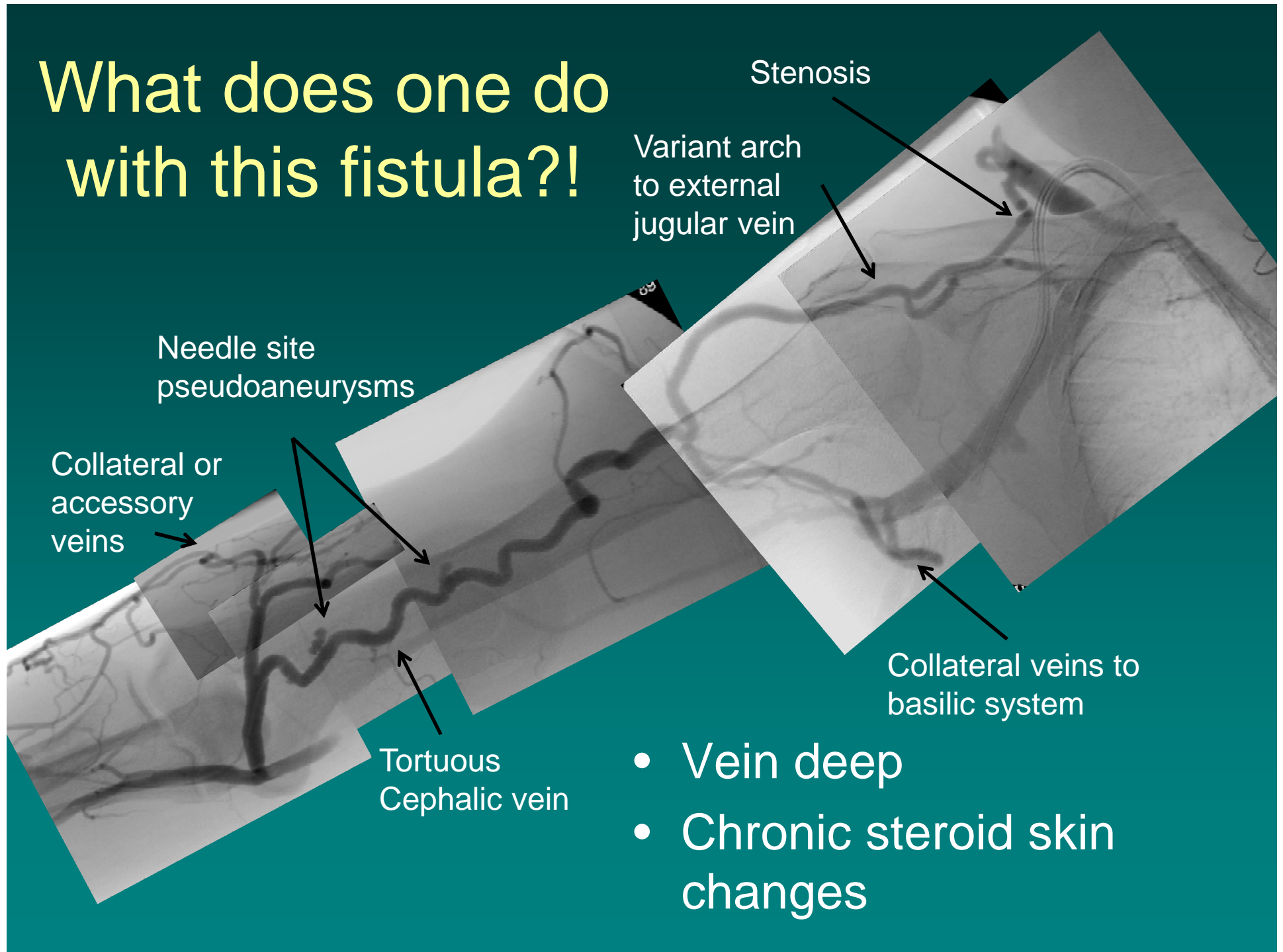
Successful cannulation?



Fistula Maturation in CKD Patients not yet Receiving HD

- Reports demonstrate effective imaging, low risk for CIN with low-dose contrast in CKD patients
 - Asif et al, Semin Dial 18:239-242, 2005
 - 25 patients CKD 4 or 5
 - Venography using 10-20 cc
 - No CIN
 - Kian et al., KI 69:1444-9, 2006
 - 34 patients CKD-4
 - 65 studies
 - Mean contrast volume 7.8 cc
 - CIN in 4.6% at one week, no sequelae, returned to baseline
- Recommend:
 - Treat AVF maturation failure in CKD patients similar to ESRD
 - Low volume contrast
 - Targeted imaging
 - Be relatively patient
 - Don't wait for thrombosis
 - Don't wait until needed to start HD

What does one do with this fistula?!



Stenosis

Variant arch
to external
jugular vein

Needle site
pseudoaneurysms

Collateral or
accessory
veins

Tortuous
Cephalic vein

Collateral veins to
basilic system

- Vein deep
- Chronic steroid skin changes

What to do with this fistula?

- Opinions solicited from interventional on-line discussion group, nephrologists, radiologists, vascular surgeons
 - Abandon & place graft in same arm
 - Abandon & create new fistula in left arm
 - Angioplasty everything in sight
 - Stent-graft entire putative puncture segment
 - Surgically straighten, transpose, turndown to basilic vein
 - Attempt to use “as-is” with buttonhole needles

AV Fistula Maturation: Summary

- A “good” fistula will have
 - Thrill & high flow immediately post-creation
 - Dominant dilated superficial vessel
- Evaluate early for poor maturation
 - Inflow stenosis
 - Calcified radial artery
 - Sclerotic vein
 - Competing vein branches
 - Deep vein
- Don’t wait months or years to intervene
 - Intervene early and often until usable or failed
 - Establish “forward progress”
- Abandon “hopeless” AVF sooner rather than later & create something better

AV Fistula Maturation Information

- Fistula First “Change Concepts”
 1. Routine CQI Review of Vascular Access
 2. Early referral to nephrologist
 3. Timely referral to surgeon for AVF “only”
 4. Surgeon selection based upon outcomes
 5. Utilize full range of techniques for AVF
 6. Secondary AVF
 7. Track catheters & convert to AVF
 8. Cannulation
 9. Monitoring & maintenance
 10. Education
 11. Outcomes Feedback