THE ACHILLES' HEEL OF HEMODIALYSIS: THE VASCULAR ACCESS

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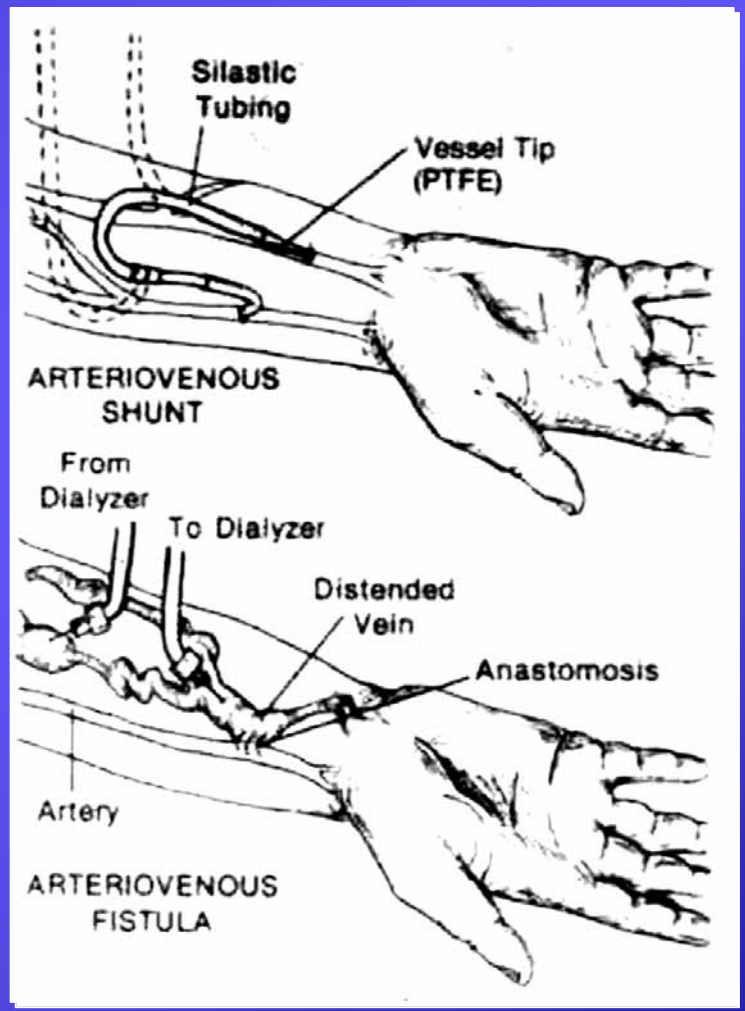
THE DEATH OF ACHILLES

HEMODIALYSIS ACCESS OPTIONS

“In my opinion, probably the most important contribution to long term survival of hemodialysis patients.” S. Shaldon



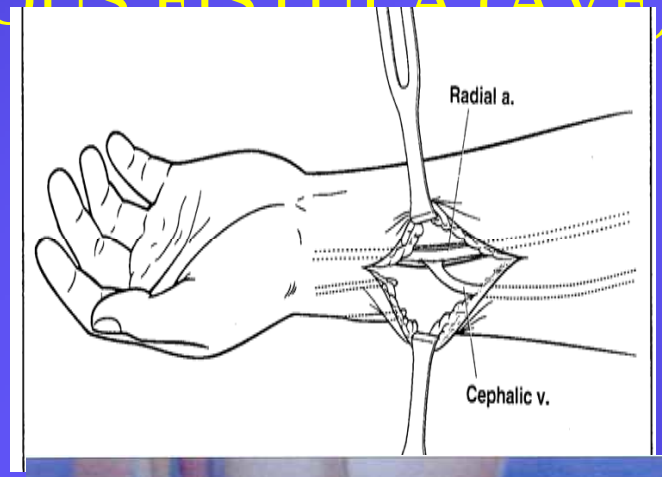
Brescia MJ, Cimino JE, Appel K, Hurwich BJ Chronic hemodialysis using venepuncture and a surgically created arterio-venous fistula. NEJM 1966;275;1089

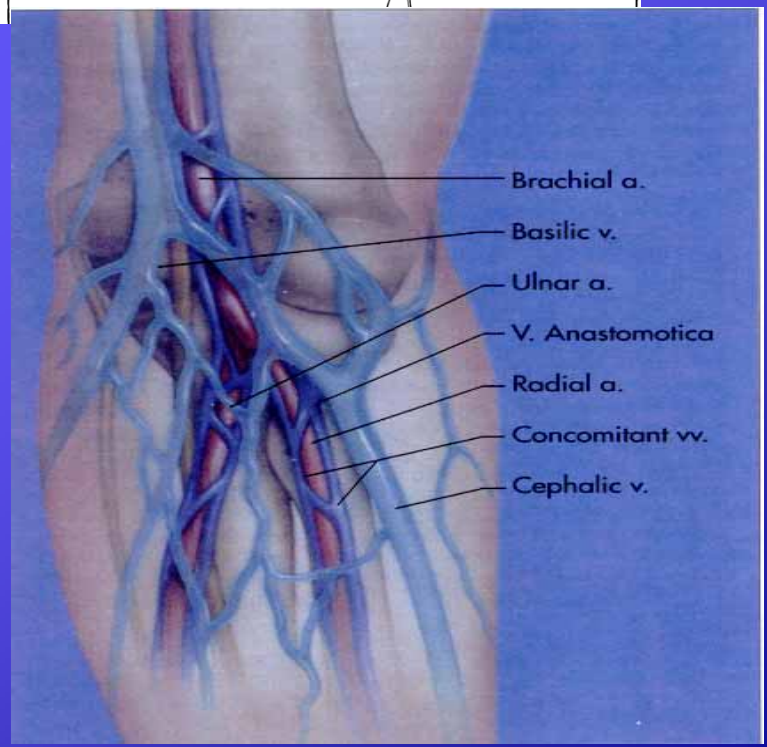
Courtesy of S. Shaldon

VASCULAR ACCESS OPTIONS: PRIMARY ARTERIO-VENOUS FISTULA (AVF)

- **ANATOMIC DESCRIPTION**

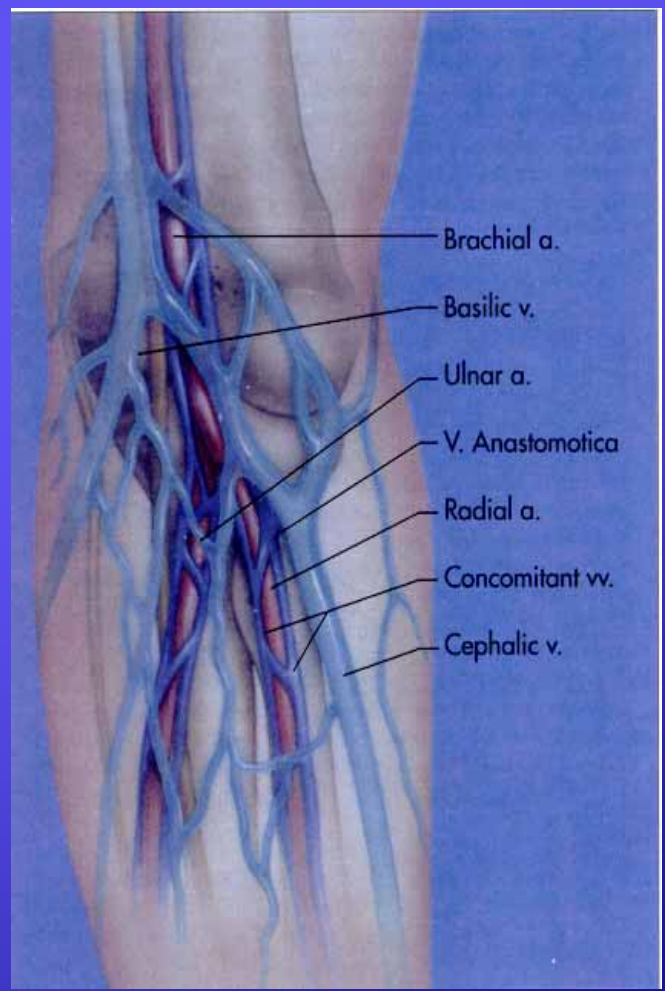
- **TYPES:**
  - **RADIAL-CEPHALIC (CIMINO-BRESCIA)**
  - **RADIAL-CEPHALIC (SNUFF-BOX)**
  - **BRACHIAL-CEPHALIC (ABOVE ELBOW)**
  - **BRACHIAL-BASILIC (TRANSPOSED)**





Vascular Access Options: Arterio-venous Grafts (AVG)

- **Anatomic Description:**
- **Types:**
  - **PTFE, ePTFE, Diastat…**
  - **Material**
  - **Distribution**
    - **Brachial-cubital fossa (loop)**
    - **Radial-cubital fossa (straight)**
    - **Radial-brachial (straight)**
    - **Brachial-brachial (loop)**
    - **Brachial-axillary (straight)**
    - **Femoral-saphenous (loop)**
    - **Femoral-femoral (loop)**
    - **Iliac-femoral (loop)**
    - **Axillary-axillary**



Vascular Access Options:
B- Arterio-venous Grafts (AVG)

- **Anatomic Description:**
- **Types:**

✉Material

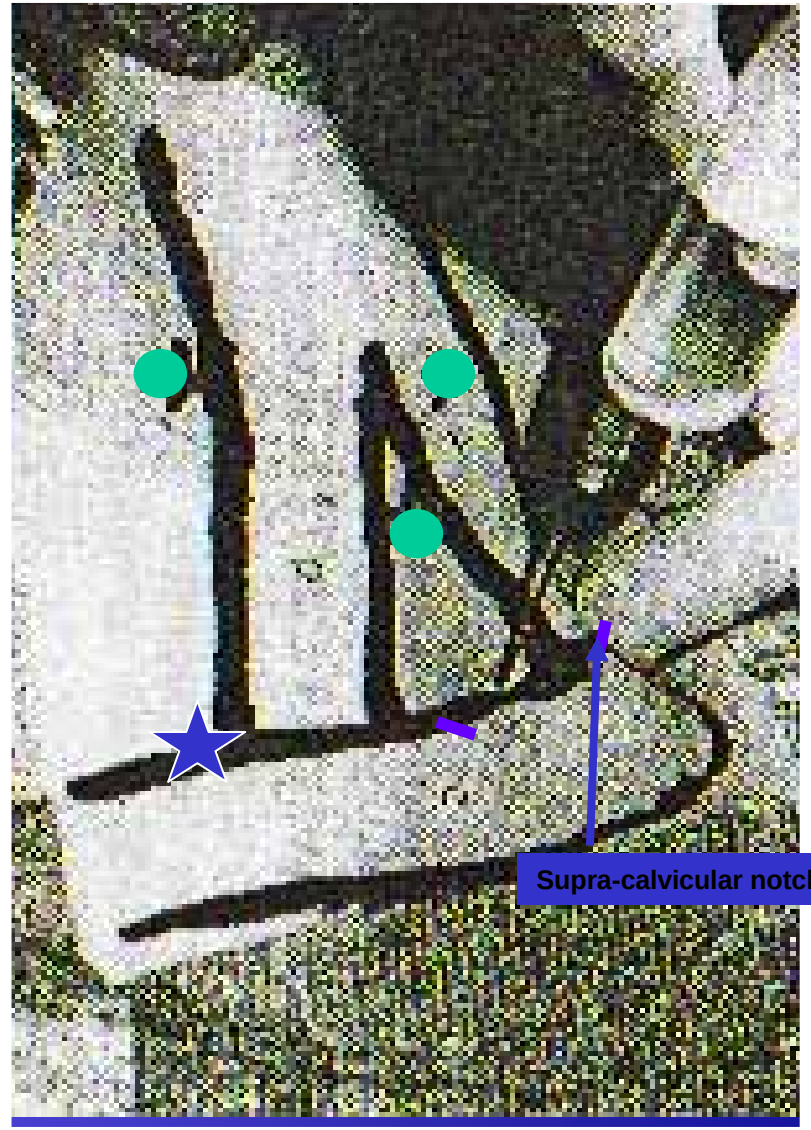
- PTFE, e-PTFE, Diastat…

✉Distribution

- Brachial-cubital fossa (loop)

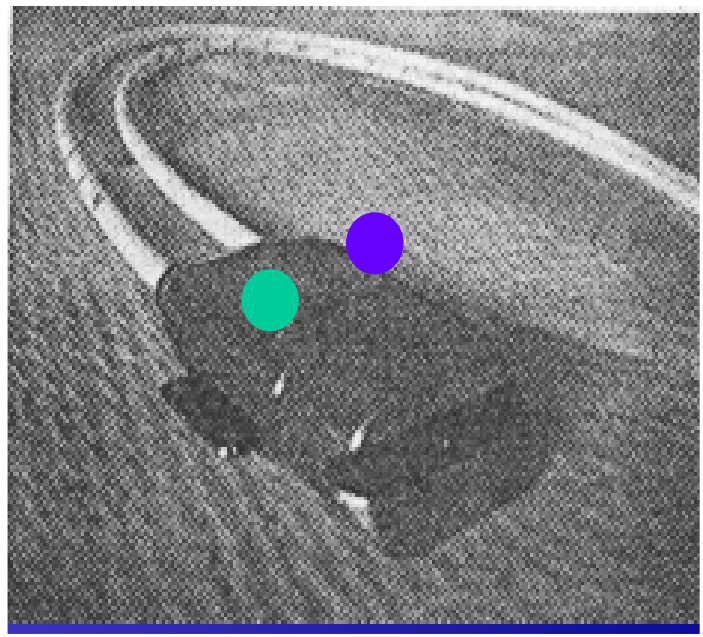
CATHETERS

- **SITES:**
  - ✉**RIGHT IJV (+++)**
  - ✉**LEFT IJV (AVOID)**
  - ✉**LEFT & RIGHT SCV (AVOID except obese)**
  - ✉**LEFT & RIGHT FV**
  - ✉**SUPRA-CLAVICULAR (LATERAL)**
  - ✉**SUPRA-CLAVICULAR (RAO)**
  - ✉**TRANS-LUMBAR (IVC)**
  - ✉**TRANS-RENAL**
  - ✉**TRANSHEPATIC !!**



CATHETERS AND IMPLANTS

- **TEMPORARY**
- **PERMANENT:**
  - ✉ **TUNNELED CATHETERS:**
    - **TESIO® (MEDCOMP)***
    - **PERM-CATH® (QUINTON)***
    - **VASCATH SOFT-CELL® (BARD)***
    - **ULDALL-COOK® (COOK)**
    - **TWIN-CATH® (MEDCOMP)**
    - **DUAL-CATH® (HEMOTEC)**
  - ✉ **IMPLANTABLE CHAMBERS:**
    - **DIALOCK® (BIOLINK)**



HEMODIALYSIS ACCCESS COMPLICATIONS

- COMPLICATIONS DUE TO ACCESS PLACEMENT PRACTICES
- COMPLICATIONS DUE TO COST
- COMPLICATIONS DUE TO MEDICAL PROBLEMS
- INTERVENTIONS TO IMPROVE OUTCOMES

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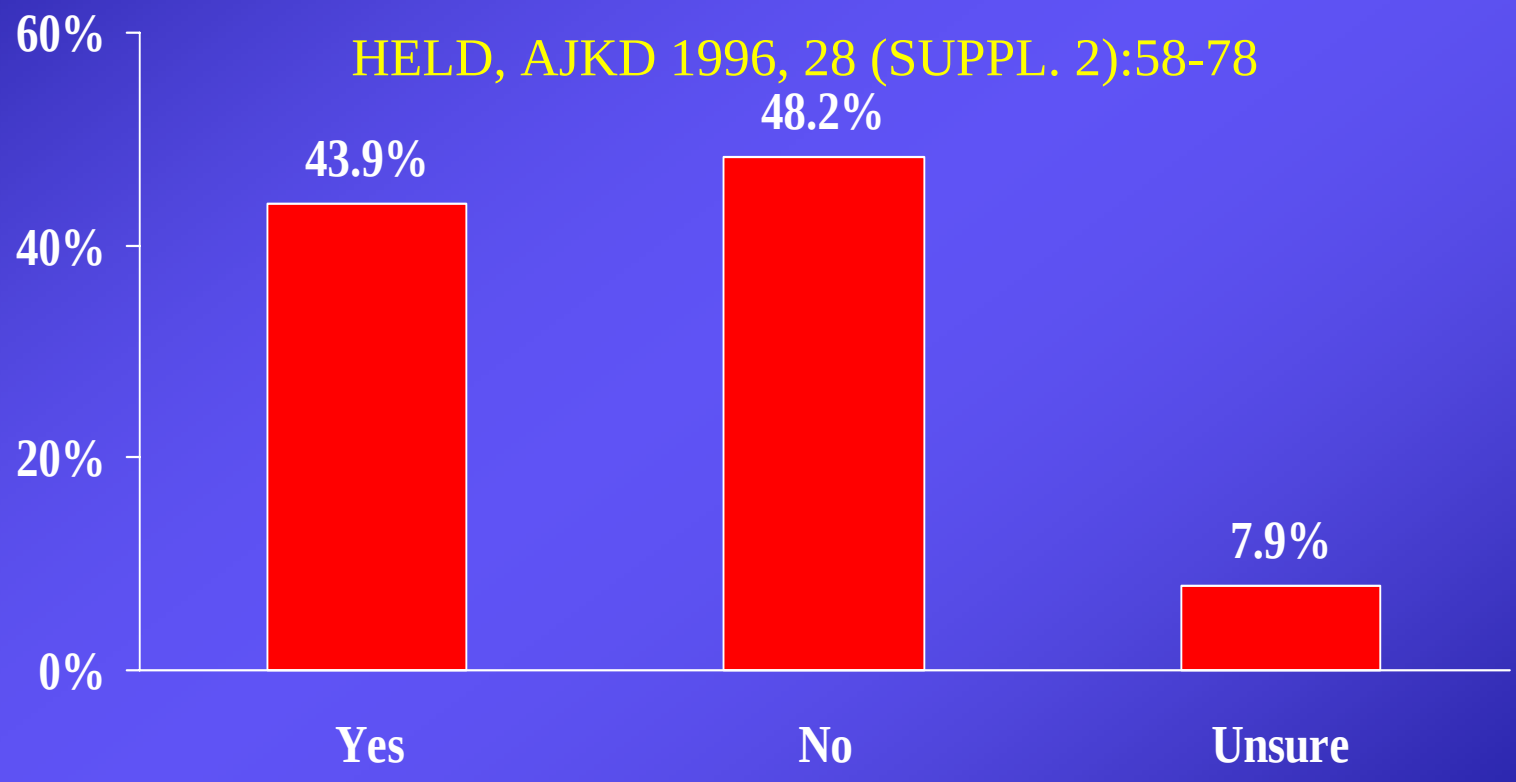
I- MAGNITUDE OF THE PROBLEM:

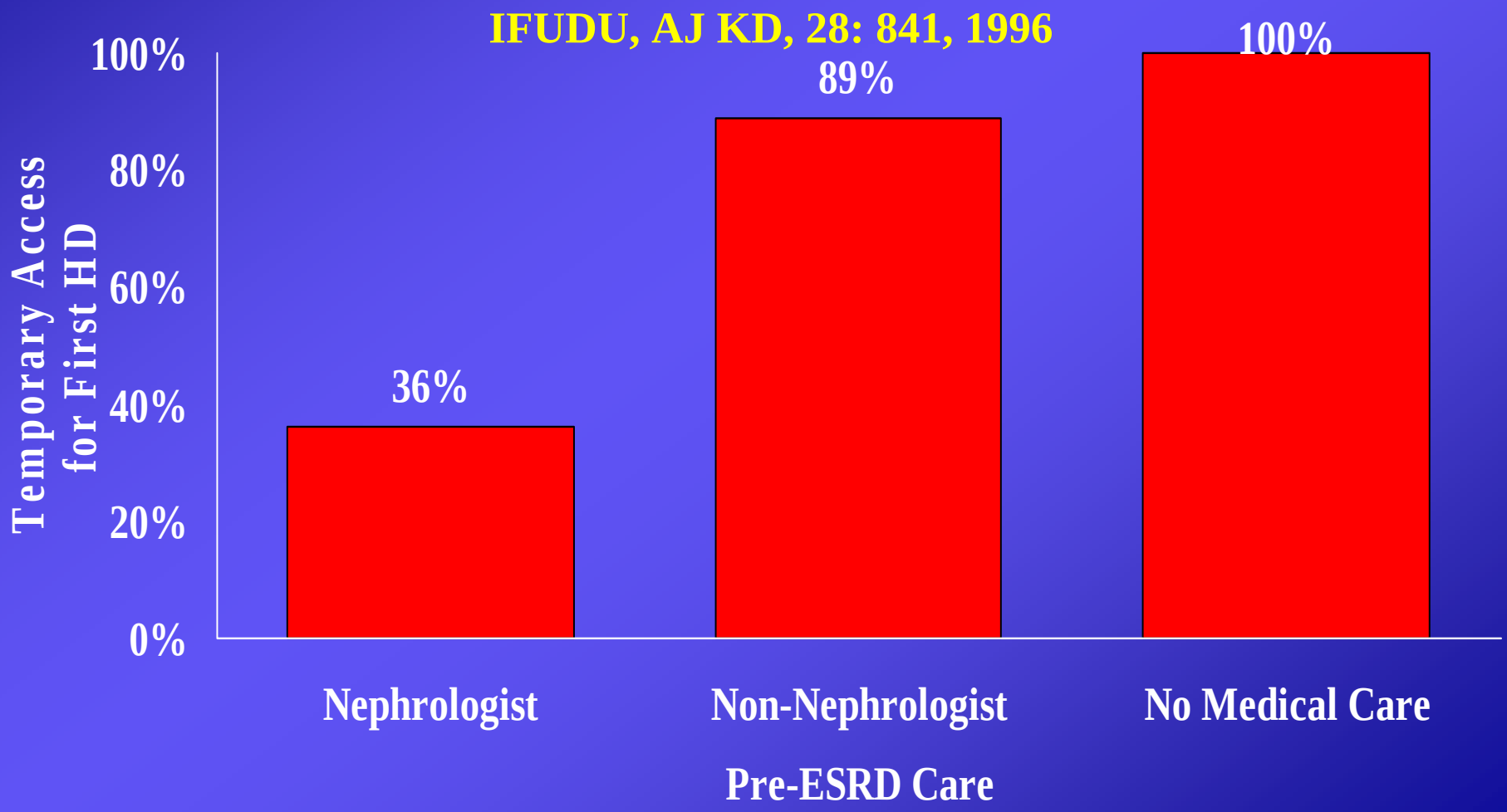
- INCREASING END-STAGE RENAL DISEASE (ESRD) POPULATION
- MORBIDITY RELATED TO VASCULAR ACCESS (VA)
- INCREASING COSTS
- PLACEMENT OF POLYTETRAFLUOROETHYLENE (PTFE) GRAFTS
- LATE REFERRAL TO THE NEPHROLOGIST & PLACEMENT OF TEMPORARY ACCESSES
- LACK OF ACCESS MONITORING PROGRAMS

FREQUENCY OF PRE-ESRD PLACEMENT OF PERMANENT DIALYSIS ACCESS IS SUB-OPTIMAL



1,997 patients incident in 1993 (USRDS DMMS Wave 1)

INDICES OF SUB-OPTIMAL PRE-ESRD CARE LACK OF PERMANENT DIALYSIS ACCESS



MAGNITUDE OF THE PROBLEM: INCREASING ESRD POPULATION

- ESTIMATED GROWTH RATE: 6-7%/YEAR
- INCIDENCE: 268/ M POP./ YR (HIGHEST AGE 70-74)
- PREVALENCE: 1041/ M POP./ YR (HIGHEST AGE 65-69)

USRDS 1998

ACCESS PRACTICE AND ITS IMPLICATIONS ON SURVIVAL

MAGNITUDE OF THE PROBLEM: HIGH MORBIDITY RELATED TO VA

- VA RELATED PROBLEMS ACCOUNTS FOR 25% OF HOSPITAL ADMISSIONS IN THE ESRD POPULATION**
- HIGHER MORBIDITY IN FEMALES!*
- HIGHER IN PATIENTS WITH PTFE AND INDWELLING CATHETERS**
- LATE REFERRAL TO THE NEPHROLOGIST***
- LINK BETWEEN VA AND DIALYSIS ADEQUACY

*** Ifudu et al, *Am J Neph*, 16(2): 118, 1996**

**** Feldman et al, *JASN,* 7(4): 523, 1996**

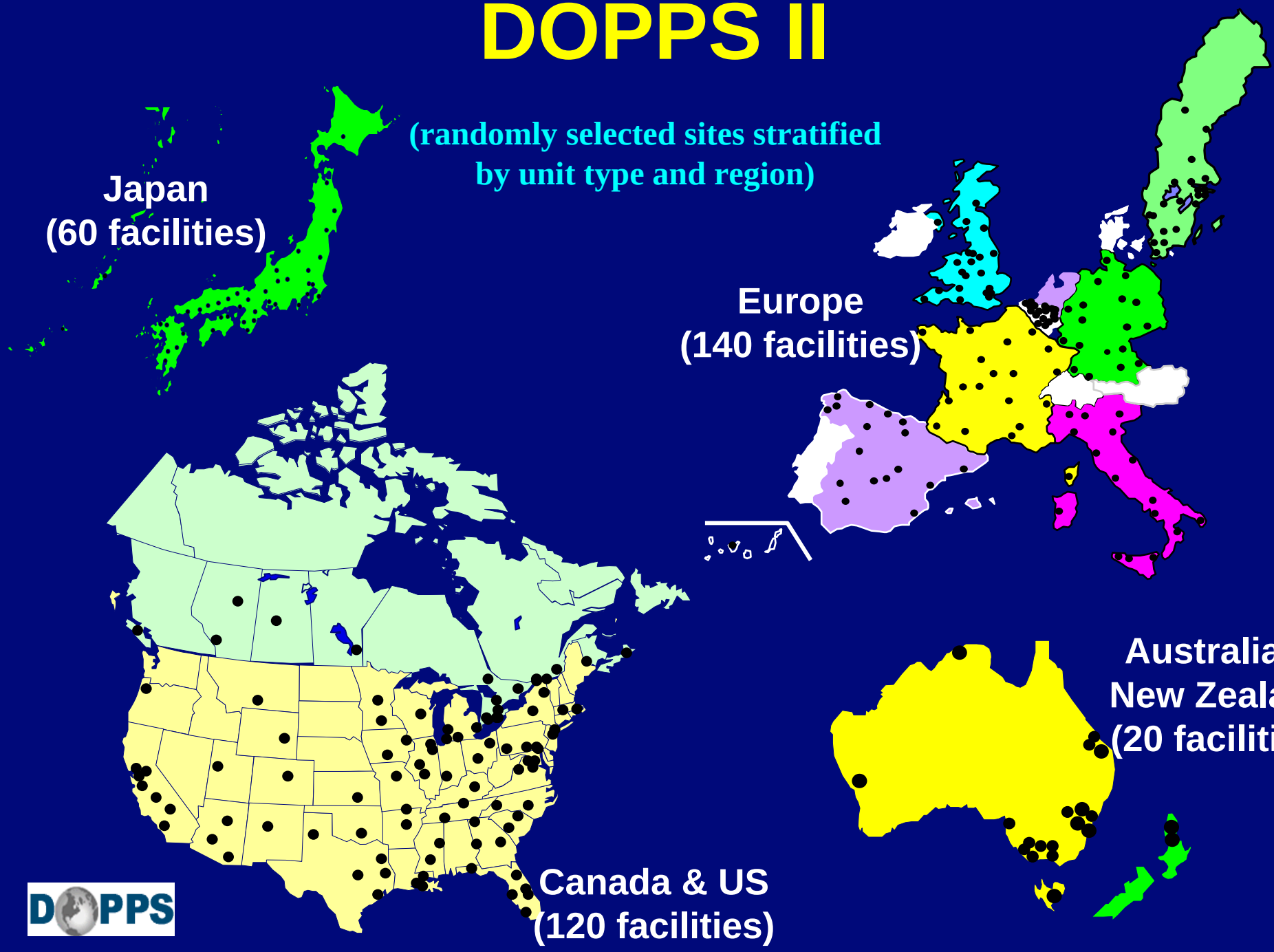
***** Chesser et al, *Clin Neph*, 51(4):228, 1999**

Dialysis Outcomes and Practice Patterns Study

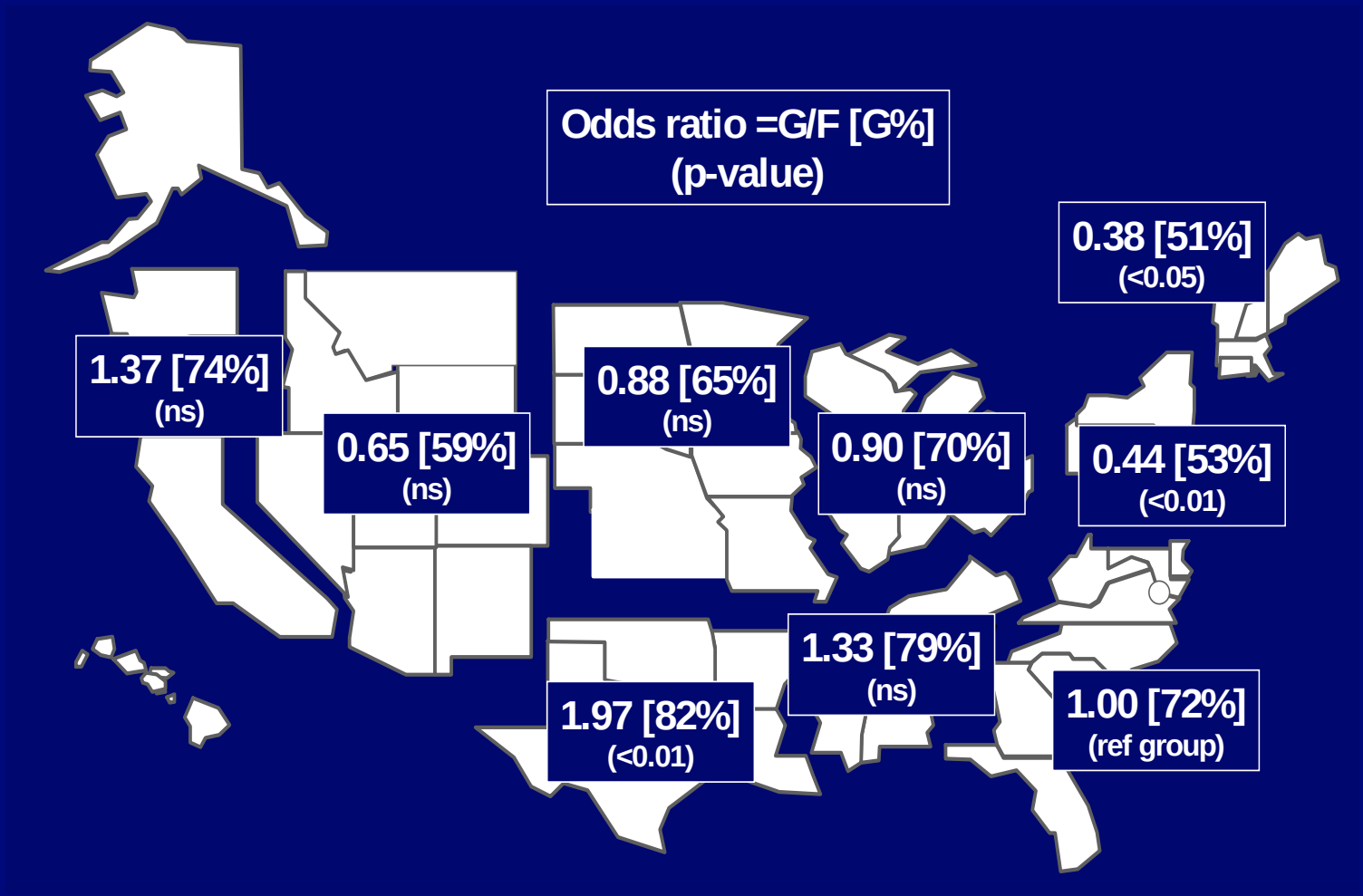
Vascular Access: Results from the DOPPS

DOPPS II

(randomly selected sites stratified by unit type and region)



Geographic Distribution of Graft Use



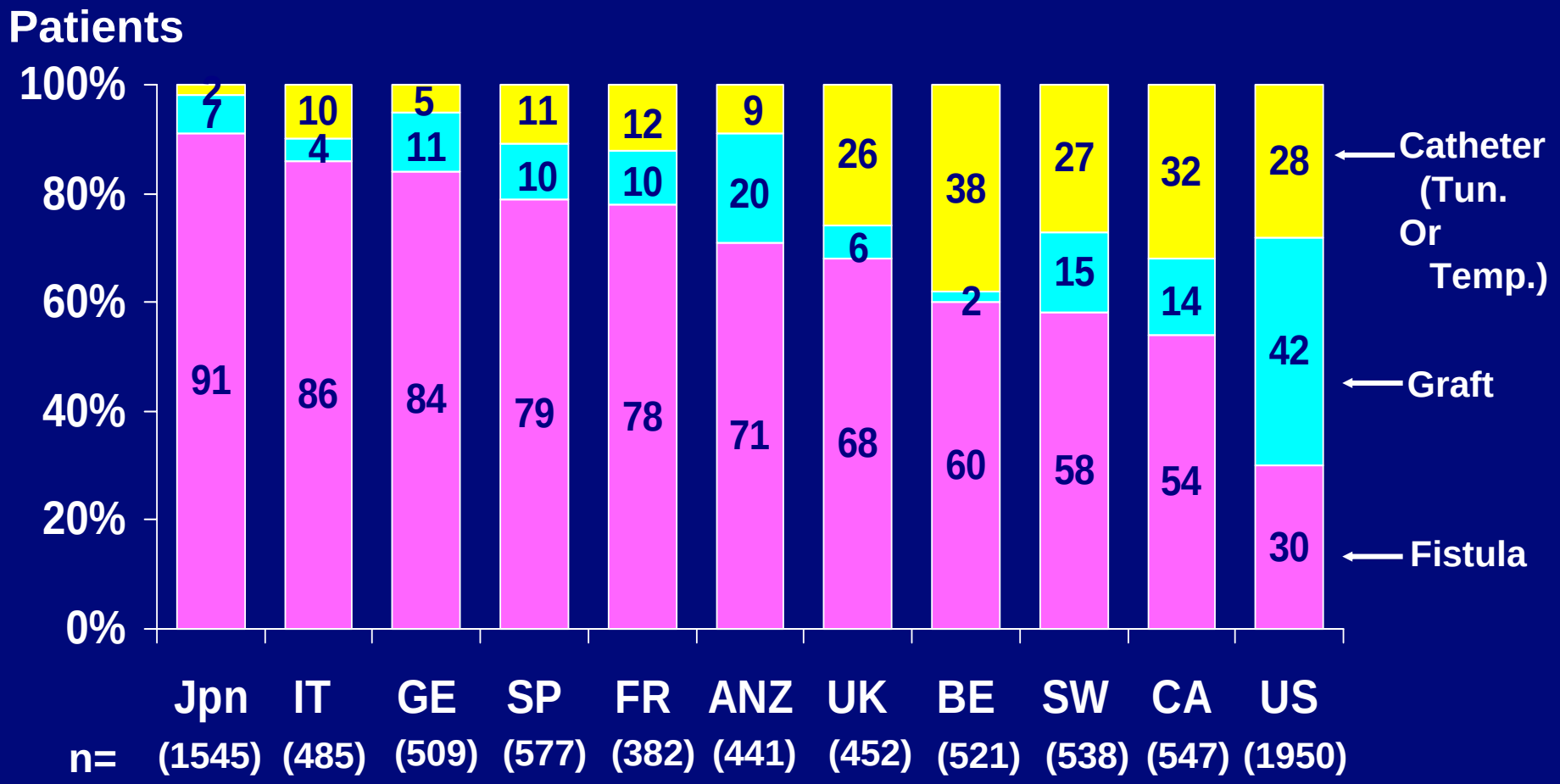
Prevalent patients in the US with permanent vascular access. The adjusted odds ratio (graft vs. fistula), percentage graft use, and P value are listed for each region. The odds ratio is adjusted for age, sex, diabetes, and peripheral vascular disease. The reference group was the overall national average, assigned an AOR of 1.0.

DOPPS I

Young EW, et. al. *Kidney International*, 2002

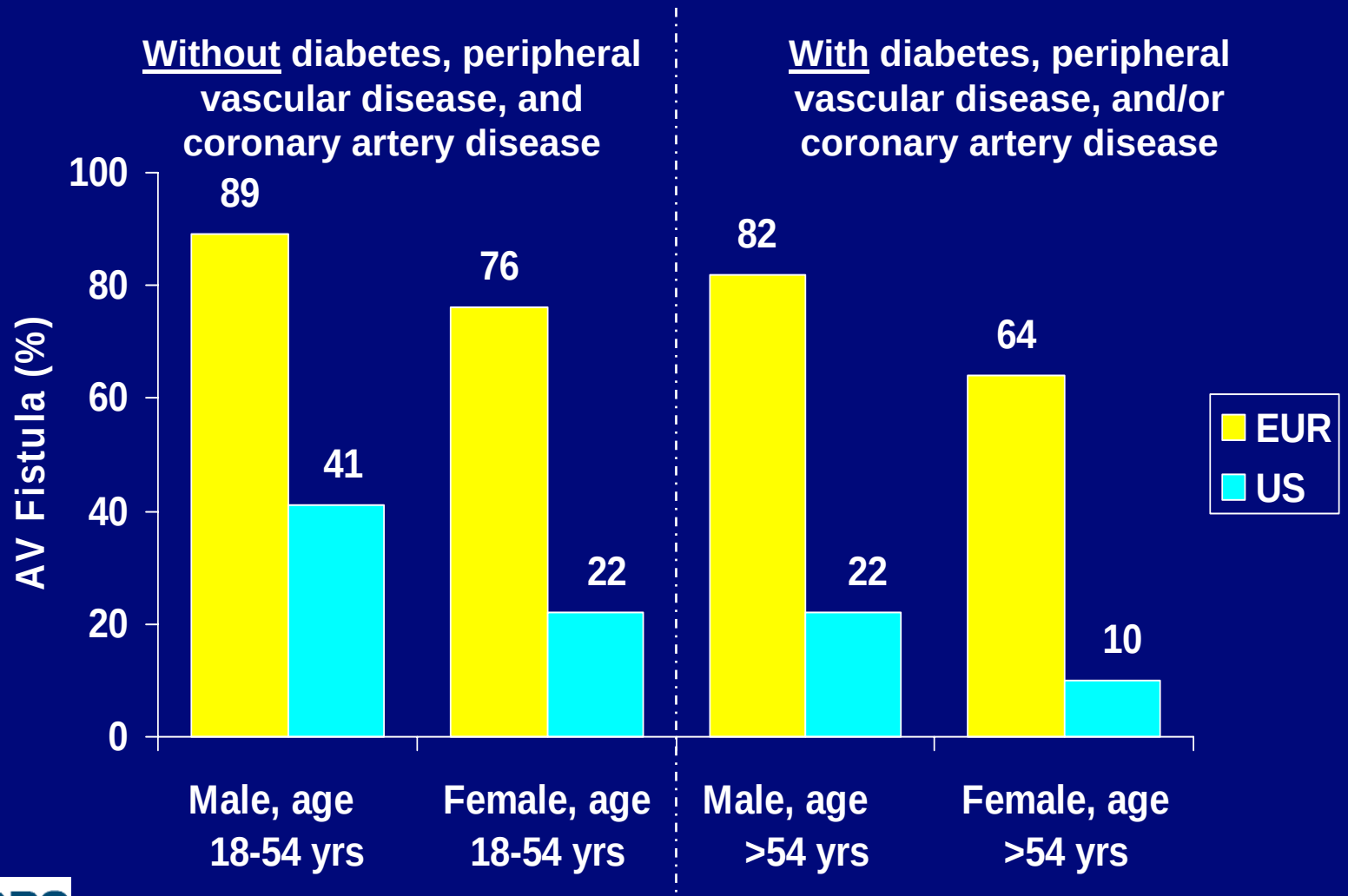
Vascular Access Use

Vascular Access Use, by Country Among Prevalent HD Patients



**Preliminary DOPPS II results as of Sept. 2003

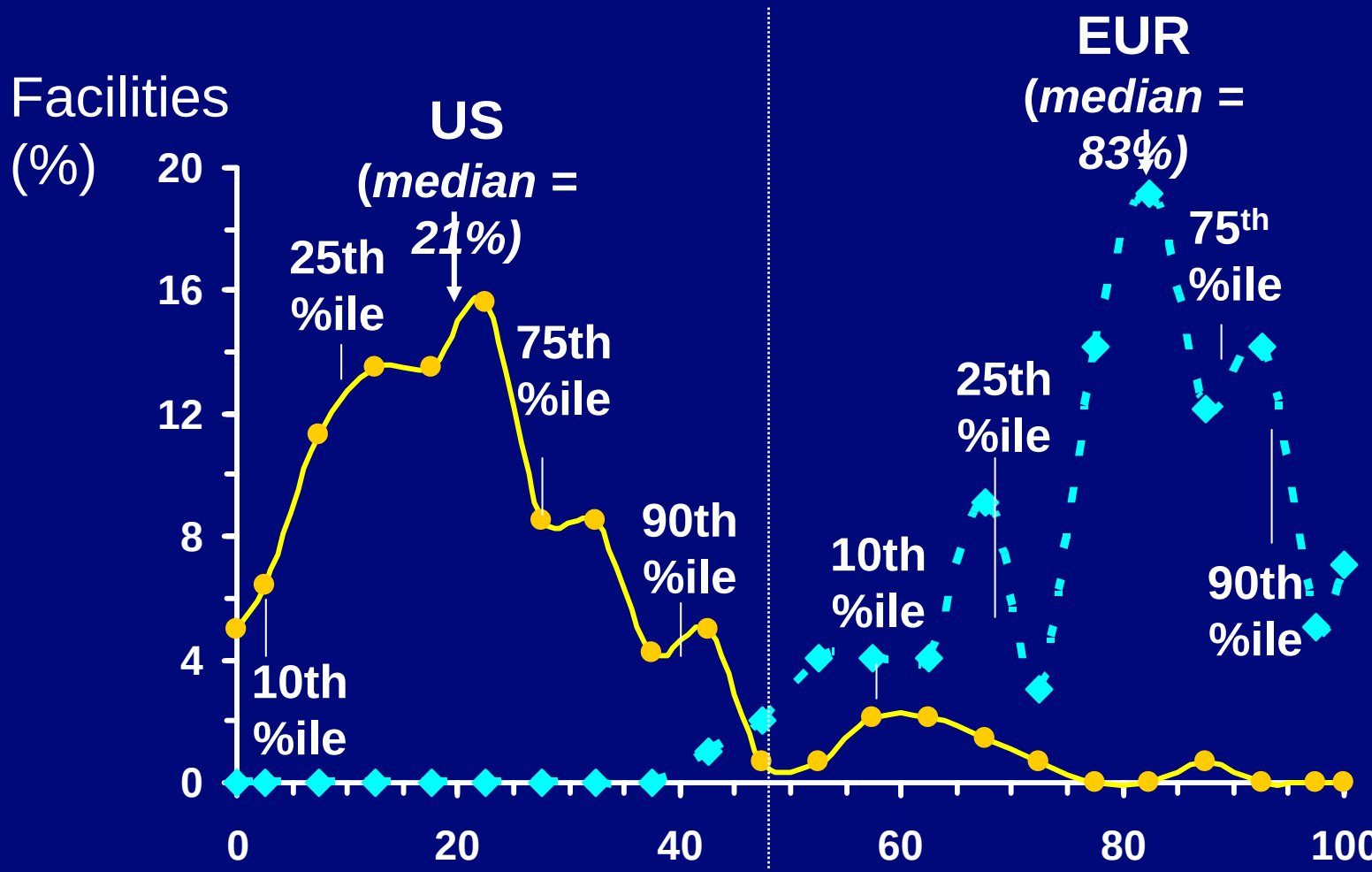
AV Fistula Use In 3 Prevalent HD Patient Subgroups: EUR and US



DOPPS I: 1997-98

Pisoni et al Kidney Int (2002) 61: 305-316.

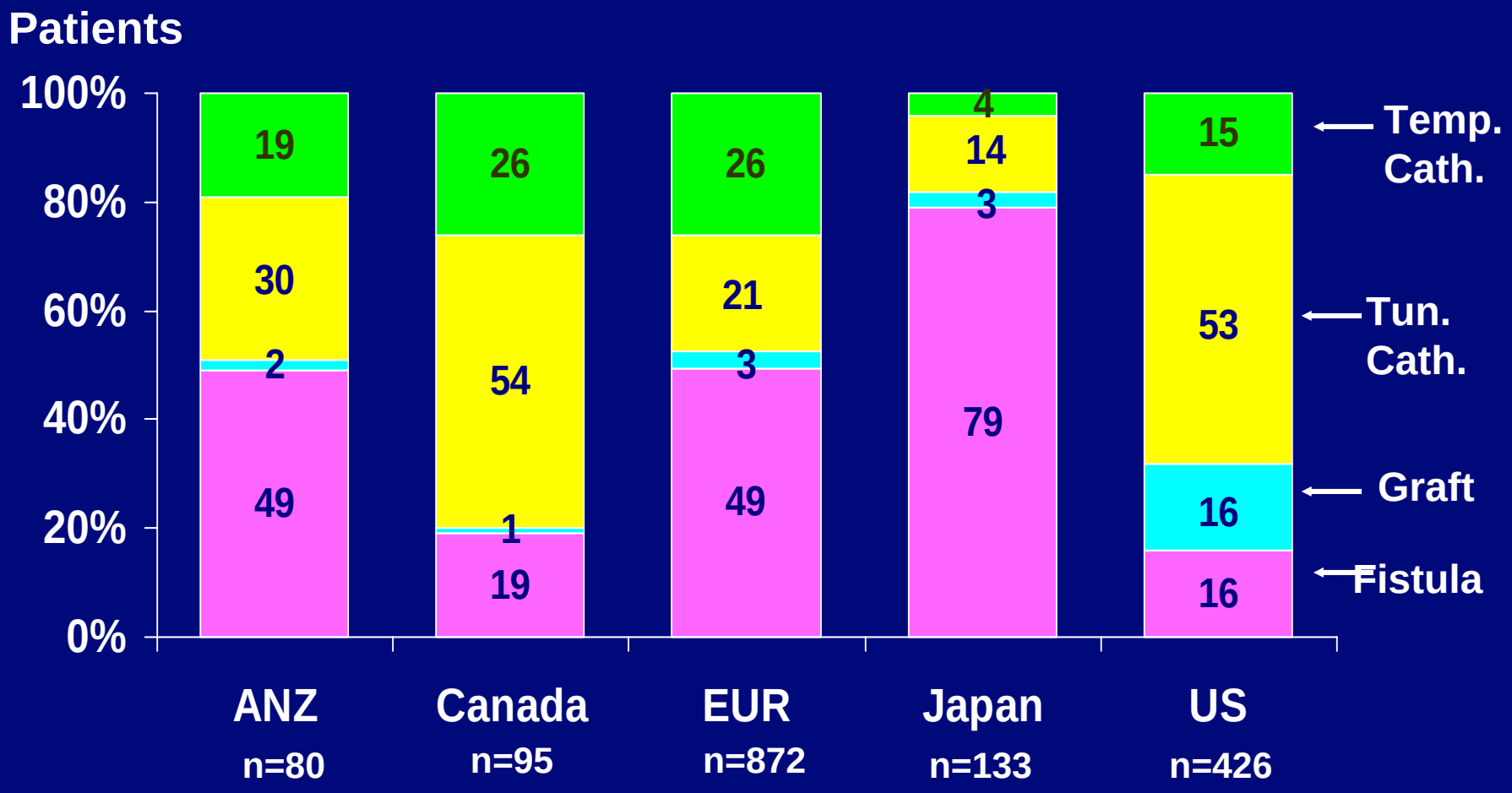
Distribution of AV Fistula Use Among Dialysis Facilities in EUR and the US



DOPPS I: 1997-98

Pisoni et al Kidney Int (2002) 61: 305-316.

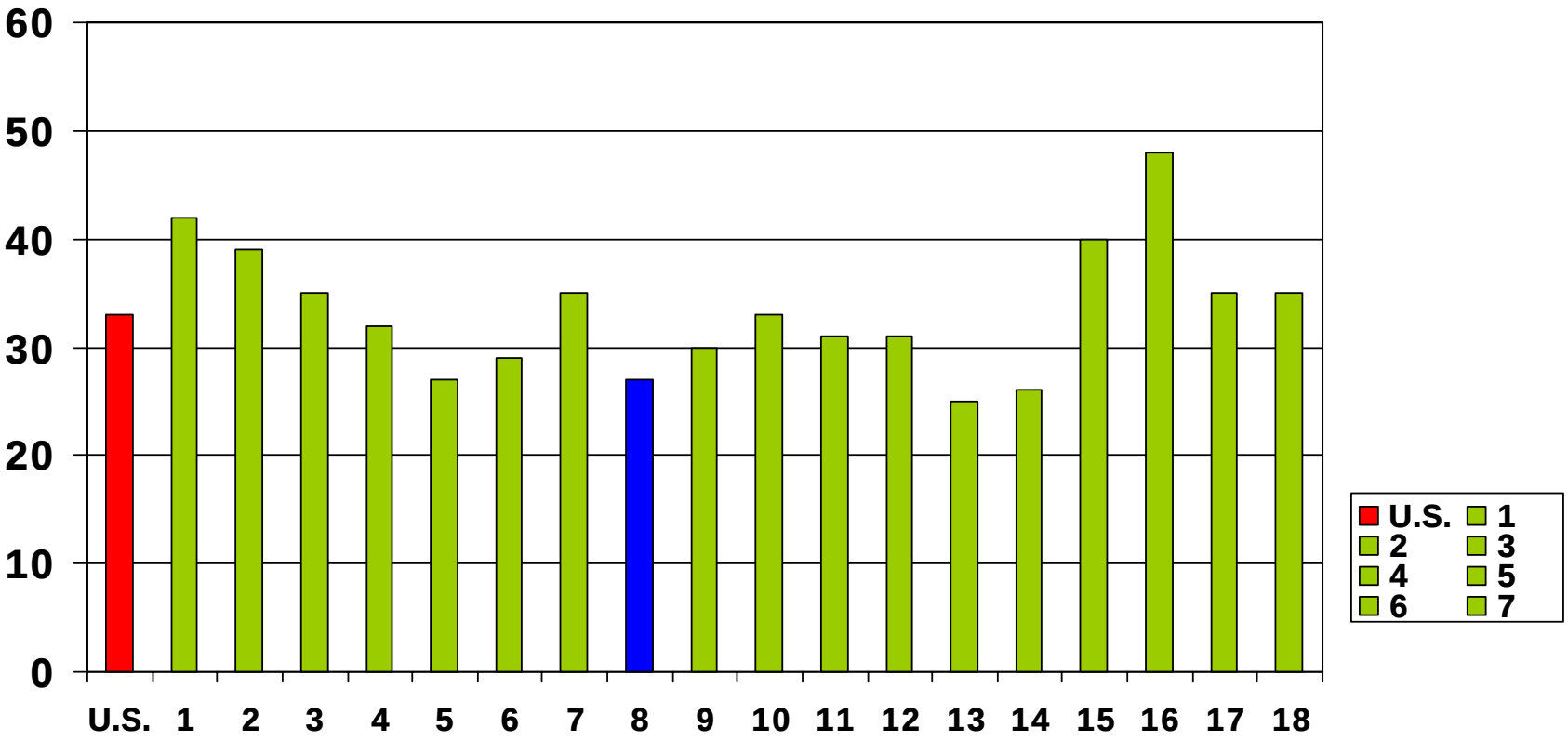
Vascular Access Use Among Incident HD Patients: DOPPS II



**Preliminary DOPPS II results as Sept. 2003

Incident patients entering DOPPS within 7 days of first-ever chronic dialysis

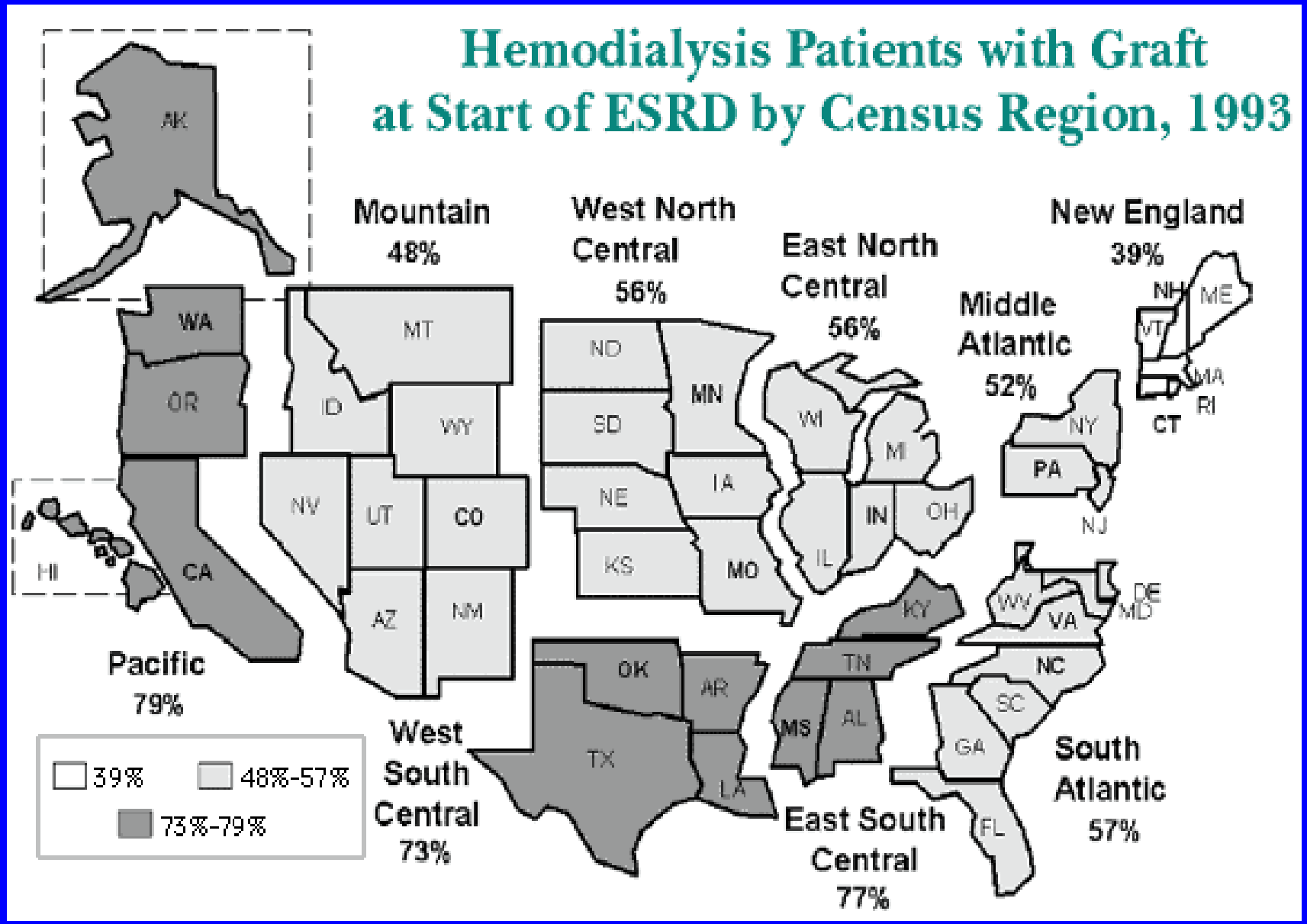
Current Patterns of AVF Use by ESRD Network



Source: 2002 CDC Data

FISTULAFIRST
National Vascular Access Improvement Initiative

CMS
CENTERS for MEDICARE & MEDICAID SERVICES



Hirth et al, JAMA, 1996

Access Procedure Rates Are Much Higher for Grafts versus Fistulae

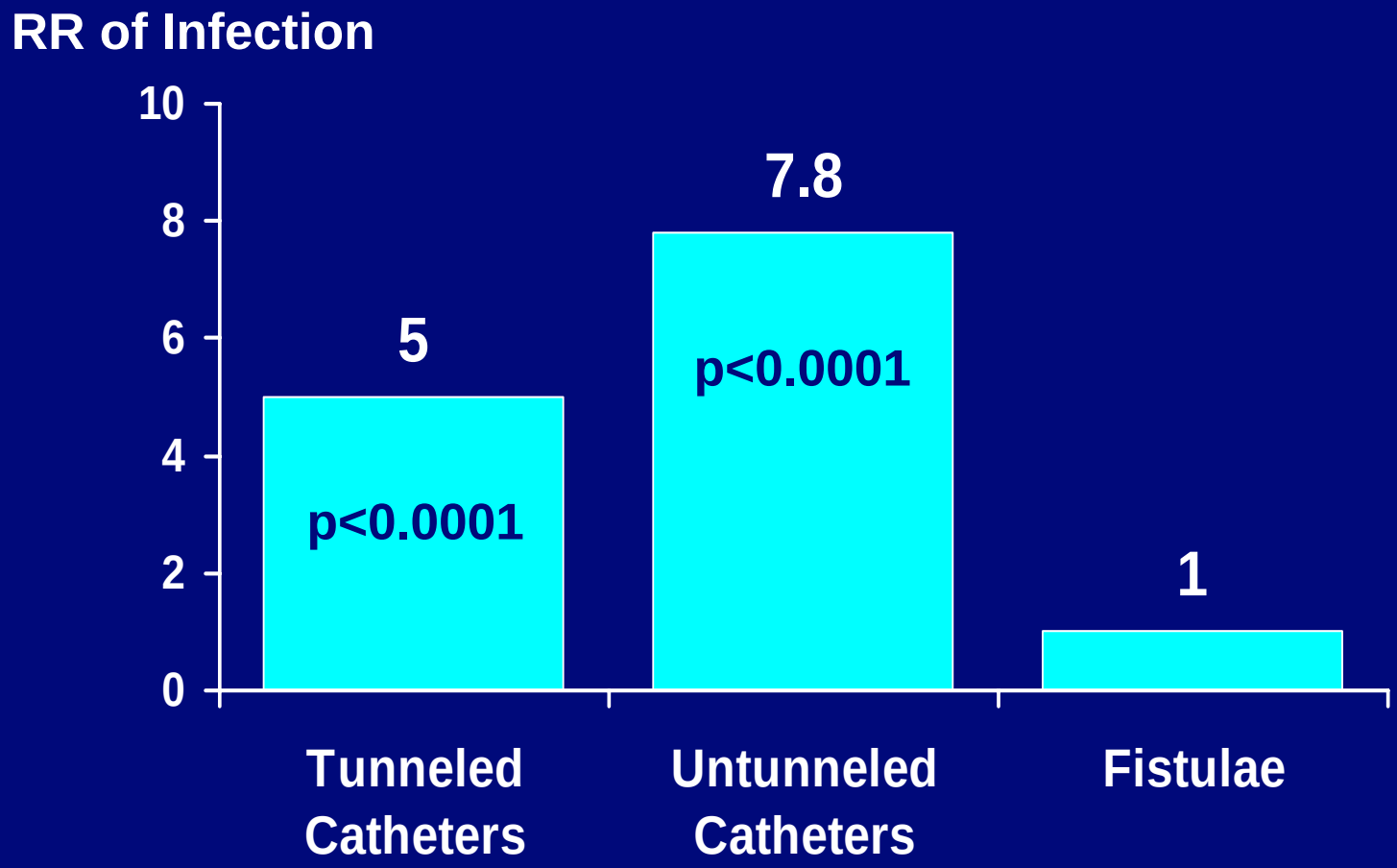
Type of Procedure	# Procedures/100 pyrs		Adjusted Relative Proc. Rate (G/F)
	Graft	Fistula	
Angiogram	7	6	1.25
Angioplasty alone	8	4	1.86†
Thrombectomy, clot lysis or revision	59	17	3.84‡
Any VA procedure	74	28	2.99‡

†p<0.05; ‡p<0.0001; * per 100 patient years; G=graft, F=fistula; adjusted for age, gender, diabetes, peripheral vascular disease, and facility clustering effects.

DOPPS

Catheter Use and Outcomes

Catheter Use Associated with High Infection Rates

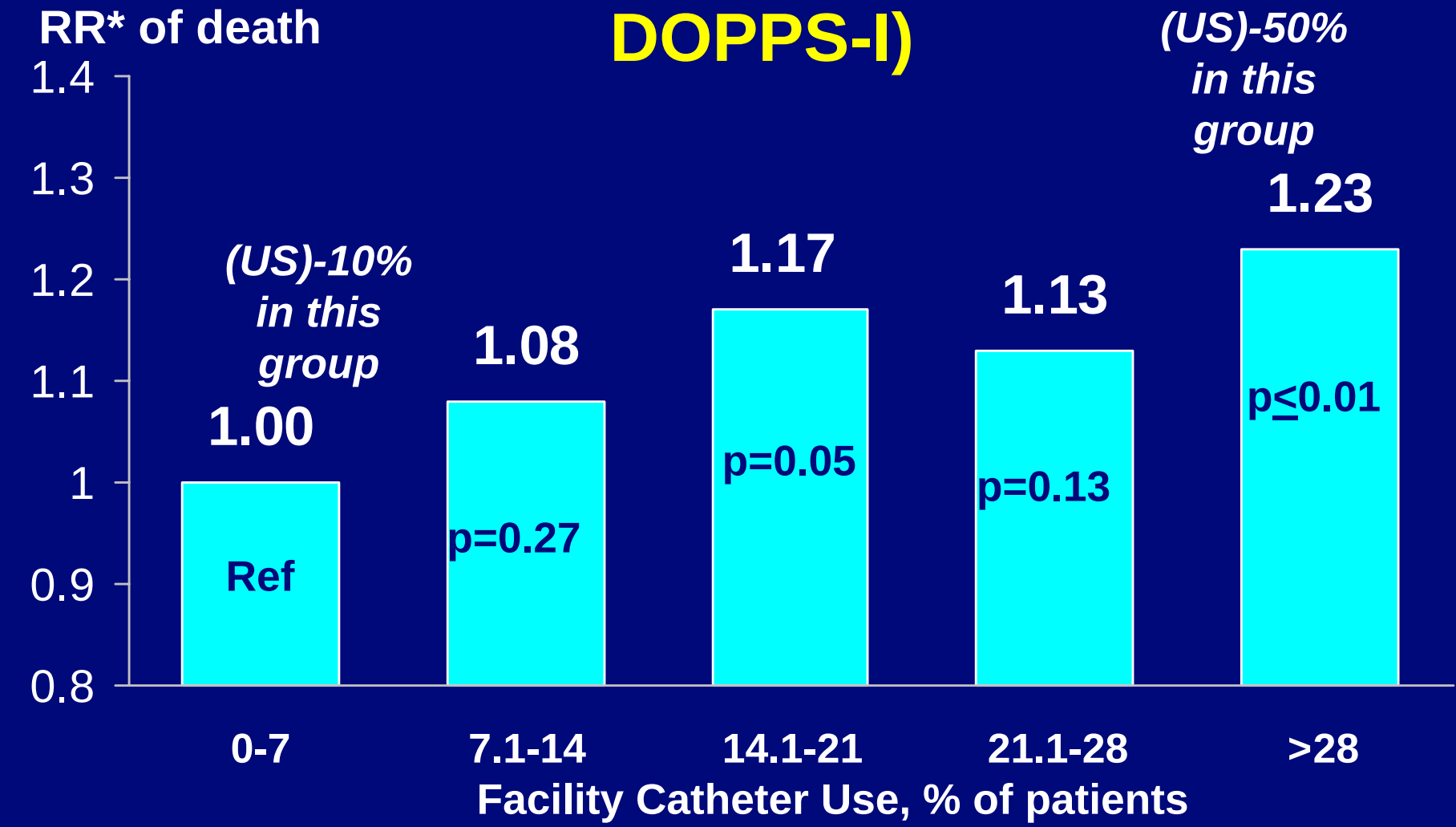


*adjusted for age, gender, continent (EUR vs US), and 15 classes of comorbidities; p values are for comparison to infection rate for fistulae. RR= Risk Ratio

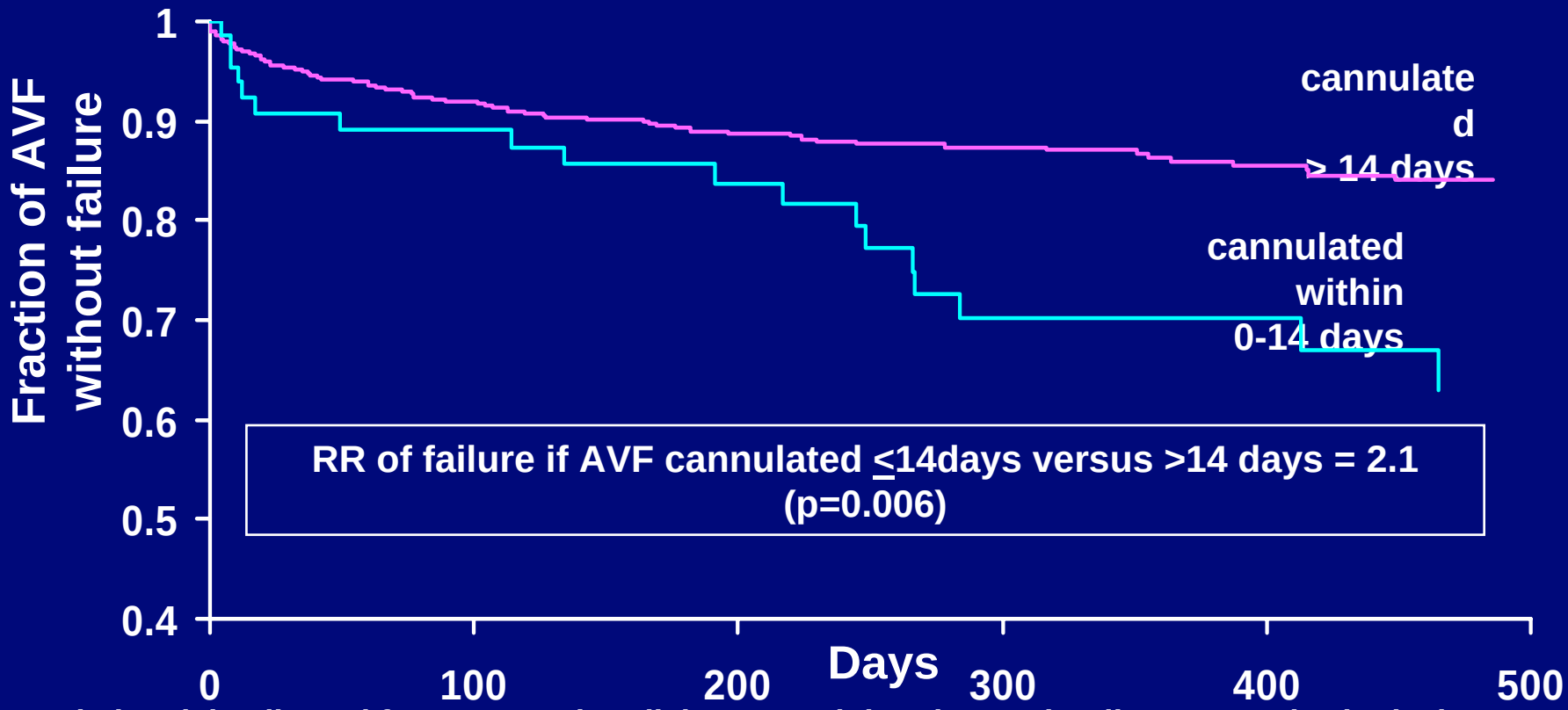
DOPPS

Combe et al, Nephrologie (2001) 22, 379-384.

Higher Facility Catheter Use Associated with Increased Mortality Risk (US and Euro-DOPPS-I)



Survival Curves for AVF Cannulated Either ≤14 Days or >14 Days



Relative risk adjusted for age, gender, diabetes, peripheral vascular disease, nephrological care prior to starting dialysis, AVF location in upper versus lower arm, country, and facility clustering effects; patients with prior temporary access excluded; AVF = AV fistula; n=642.

DOPPS

Rayner HC, et. al. *Kidney International*, 2003

THERE ARE ONLY TWO TYPES OF CATHETERS:
THOSE THAT ARE INFECTED AND THOSE THAT WILL BE INFECTED.

Odds of Starting HD with Permanent AV Access versus Catheter by 2 Practice Patterns

Practice Pattern	*Adjusted Odds Ratio (AOR)**	*p-value*
Seen by nephrologist > 1 month prior to ESRD (yes v. no)	6.1	< 0.001
VA surgery within ≤ 2 weeks of referral (yes v. no)	1.8	0.002

* AOR adjusted for age, gender, diabetes, PVD, BMI, pre-ESRD care, facility clustering effects; DOPPS I n=2073)

Pisoni et al Kidney Int (2002) 61: 305-316.

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- **COMPLICATIONS DUE TO COST**
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INCREASING COST

- TOTAL ESRD SPENDING (1996): $14.55 BILLION ($43,563/ PT-YR AT RISK)

USRDS 1998

- ACCESS RELATED SPENDING (1994): ≈$1 BILLION,

  ≈$8000/PT-YR AT RISK

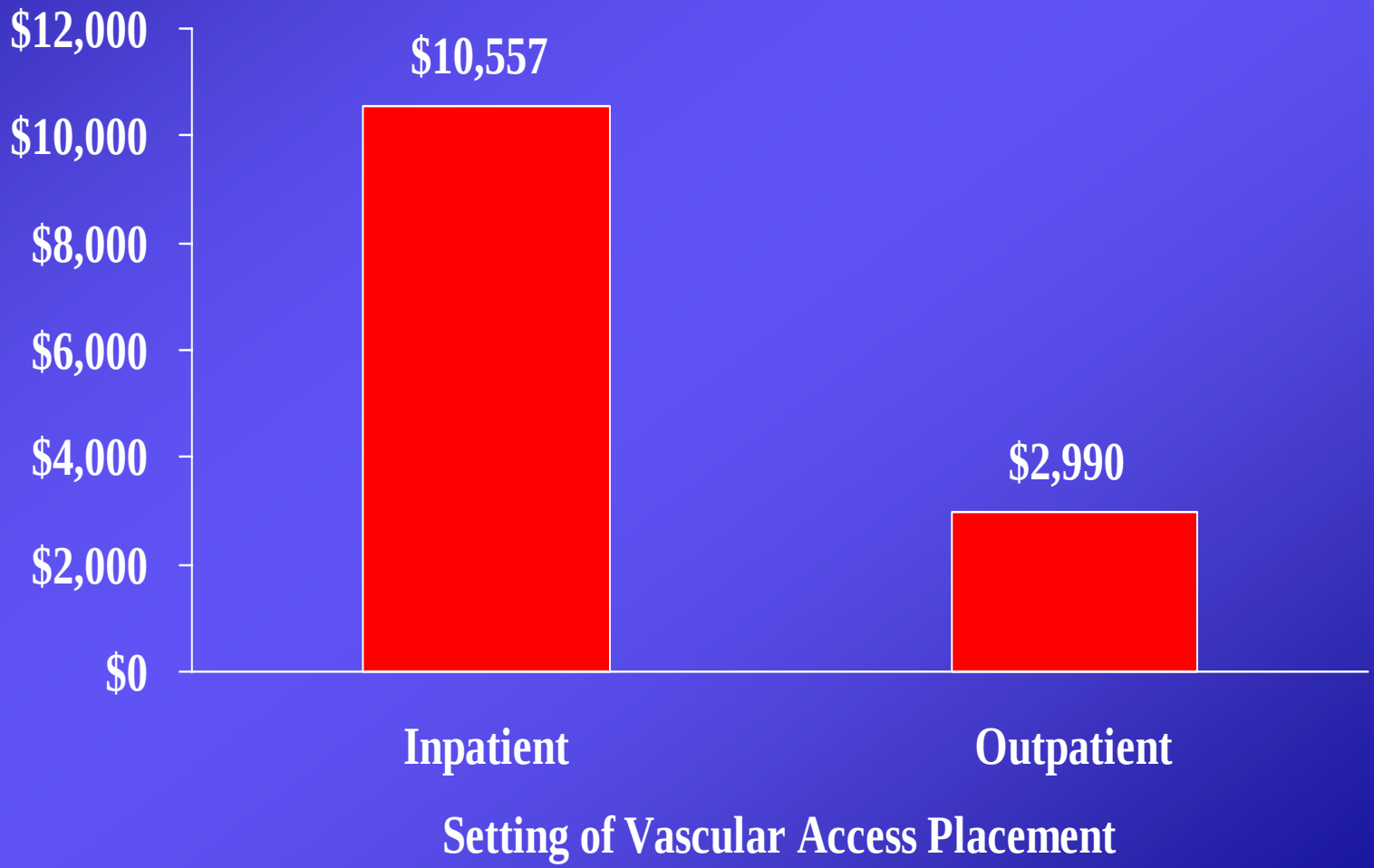
USRDS 1997, *AJKD* 30(2):S160, 1997

- COST INCREASES WITH PTFE, PARTLY II° TO PROCEDURES NEEDED TO MAINTAIN PATENCY

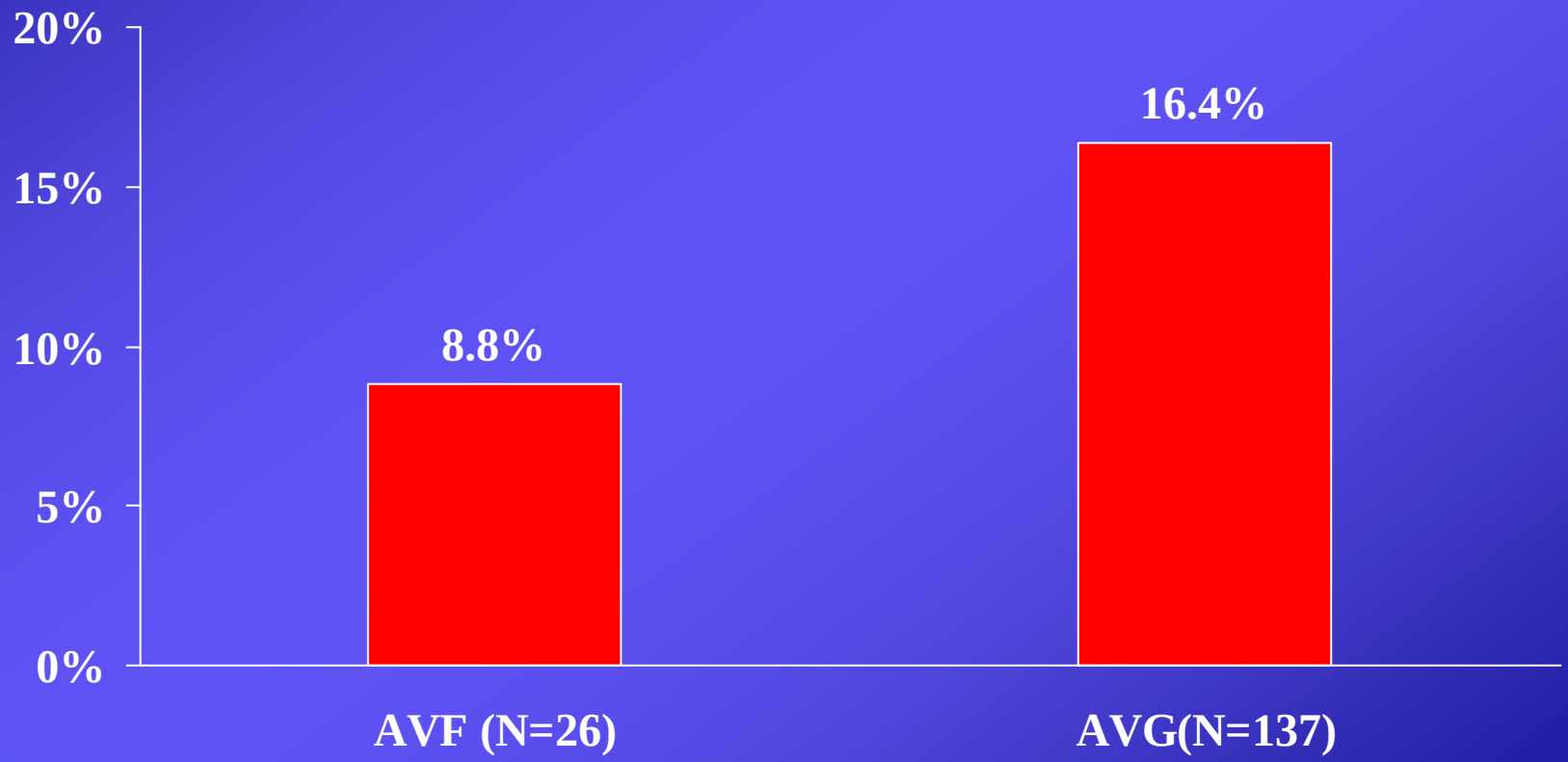
Feldman et al, *JASN,* 7(4): 523, 1996

ELECTIVE OUTPATIENT VASCULAR ACCESS PLACEMENT COSTS LESS

BLEYER, NEPHROLOGY NEWS AND ISSUES JAN 1995: 19-22



ARTERIOVENOUS GRAFTS ARE MORE LIKELY TO REQUIRE REVISION THAN FISTULAS



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VASCULAR ACCESS: STENOSIS AND THROMBOTIC COMPLICATIONS

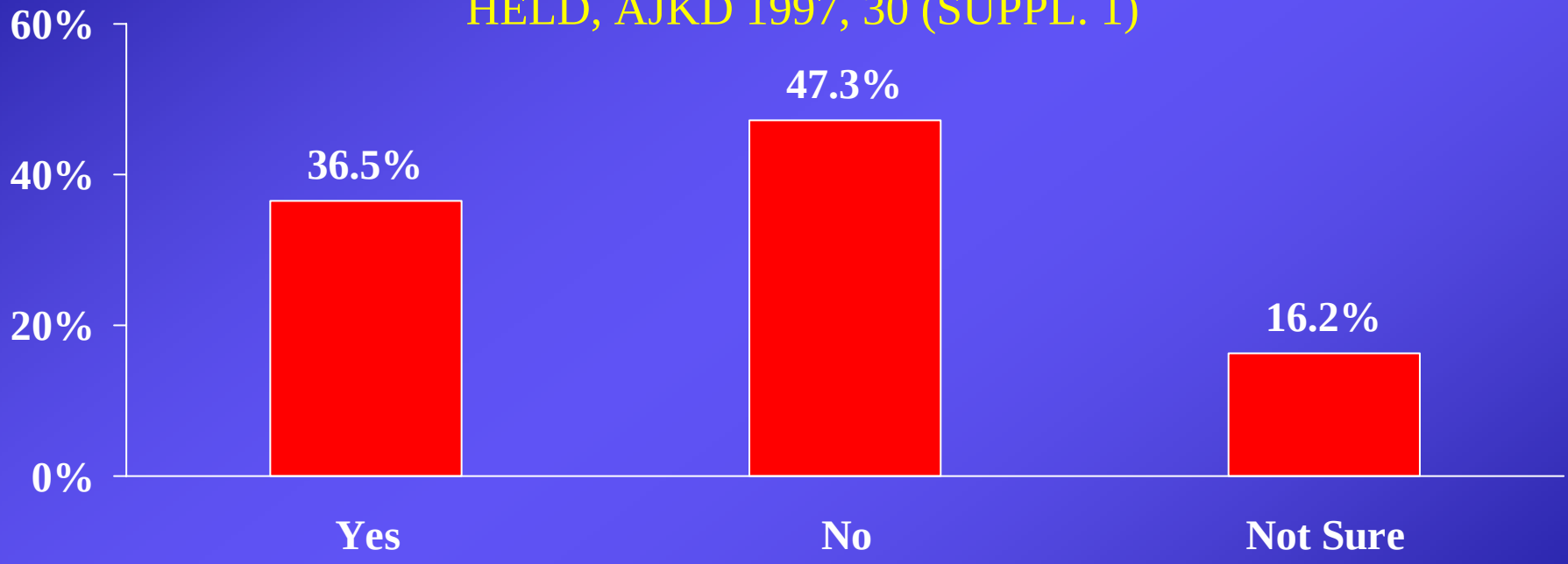
- NONMATURATION
- STENOSIS
- THROMBOSIS
- ACCESS FAILURE

NONMATURATION OF THE ACCESS

- ASSOCIATED WITH AVF
- CAUSES
  - NARROW VEINS/DESTROYED VEINS
  - COLLATERAL VEINS
  - VENOUS STENOSIS
  - ARTERIAL INSUFFICIENCY
- MAY BE SALVAGED
  - 44-82% REPEATED PROCDURES REQUIRED
  - 75% 1 YR PATENCY
    - (BEATHARD ET AL, AJKD, 1999/ MILLER ET AL KI, 2003)

PATIENTS ARE INFREQUENTLY INSTRUCTED TO PROTECT THE ARM FOR VASCULAR ACCESS

HELD, AJKD 1997, 30 (SUPPL. 1)



1,238 patients, USRDS Dialysis Morbidity and Mortality Study - Wave 2

STENOSIS AND THROMBOSIS

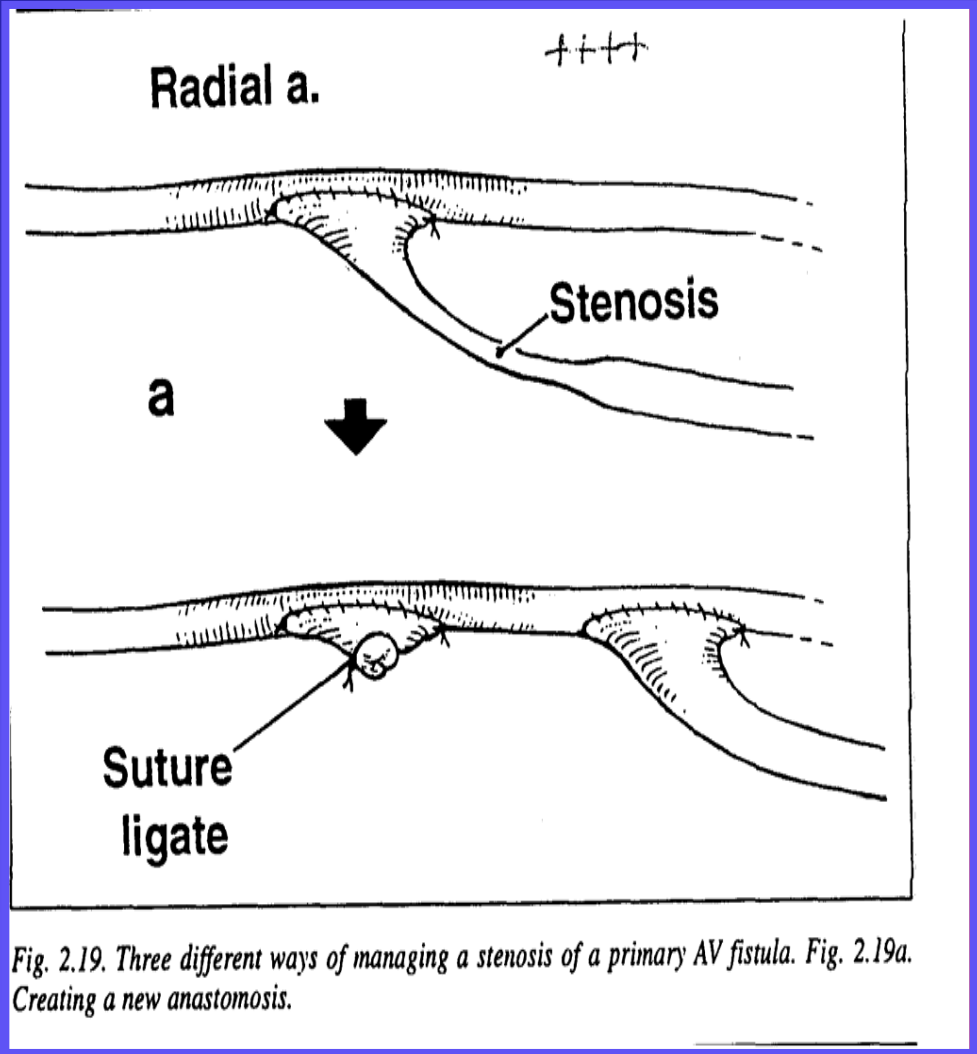
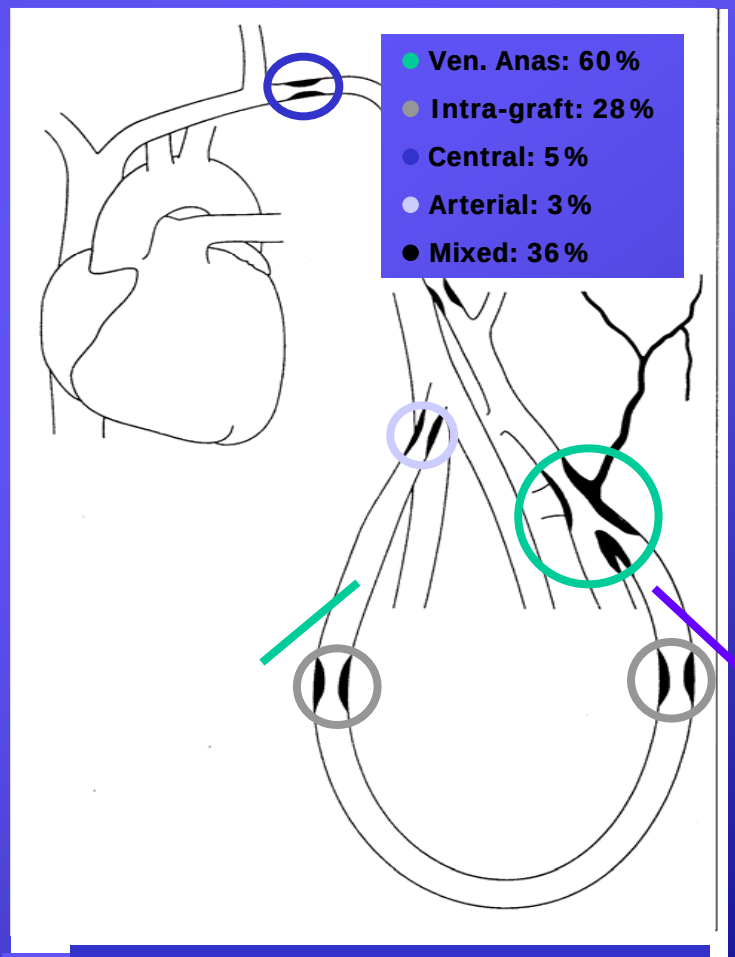


Fig. 2.19. Three different ways of managing a stenosis of a primary AV fistula. Fig. 2.19a. Creating a new anastomosis.

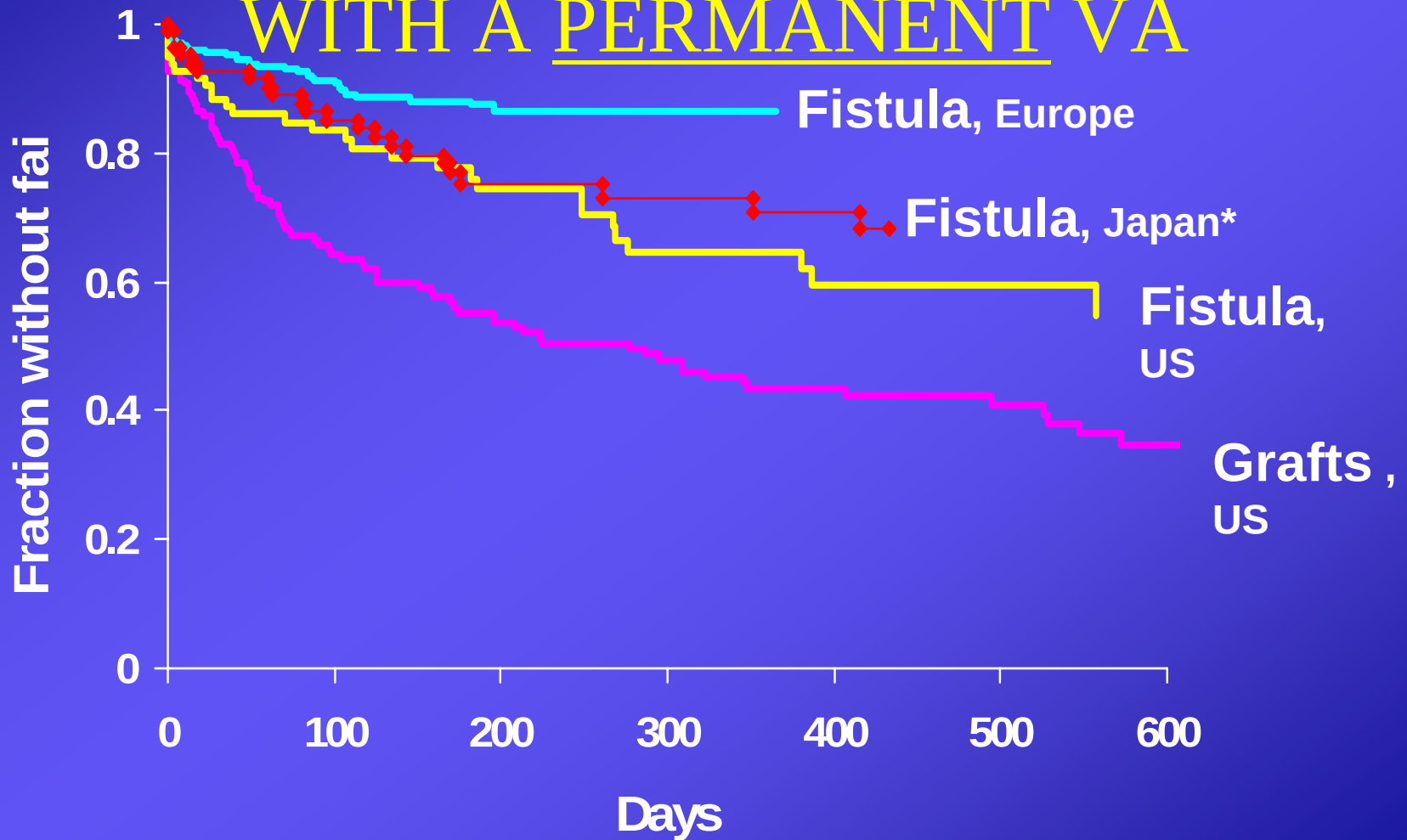


Beathard, *Sem Dial*, 8(3), 166, 1995

ACCESS FAILURE

- FISTULA THROMBOSIS (LESS THAN 0.25 EPISODES/PATIENT-YEAR AT RISK)
- FISTULA PATENCY (GREATER THAN 3.0 YEARS)
- GRAFT THROMBOSIS (LESS THAN 0.5 EPISODES/PATIENT-YEAR AT RISK)
- GRAFT PATENCY (GREATER THAN 2.0 YEARS)

FISTULA AND GRAFT SURVIVAL IN INCIDENT PATIENTS STARTING HD WITH A PERMANENT VA

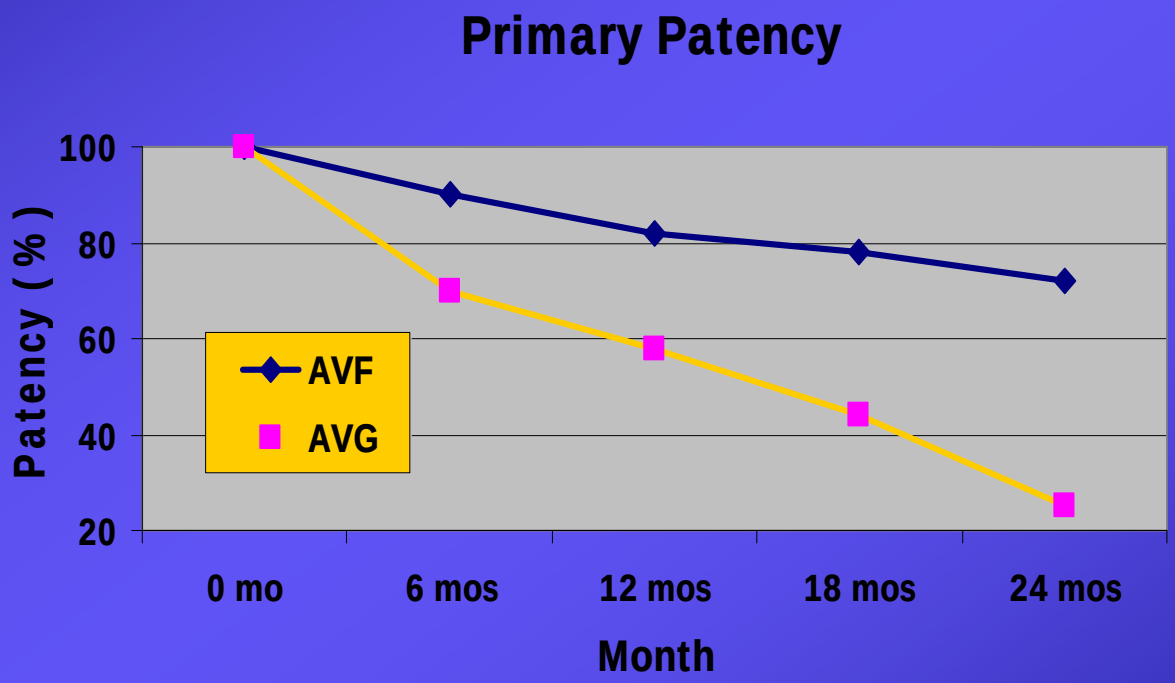


Adjusted for differences in age, gender, diabetes, and peripheral vascular disease; *note: in Japan, there were only a small number (n= 88) of incident patients for analysis so confidence interval (C.I.) at one year is much larger than for other countries; in Japan, 1 year AV Fistula survival C.I.=0.60-0.87.

DOPPS I

Pisoni et al Kidney Int (2002) 61: 305-316.

VASCULAR ACCESS OPTIONS: AVF VS AVG

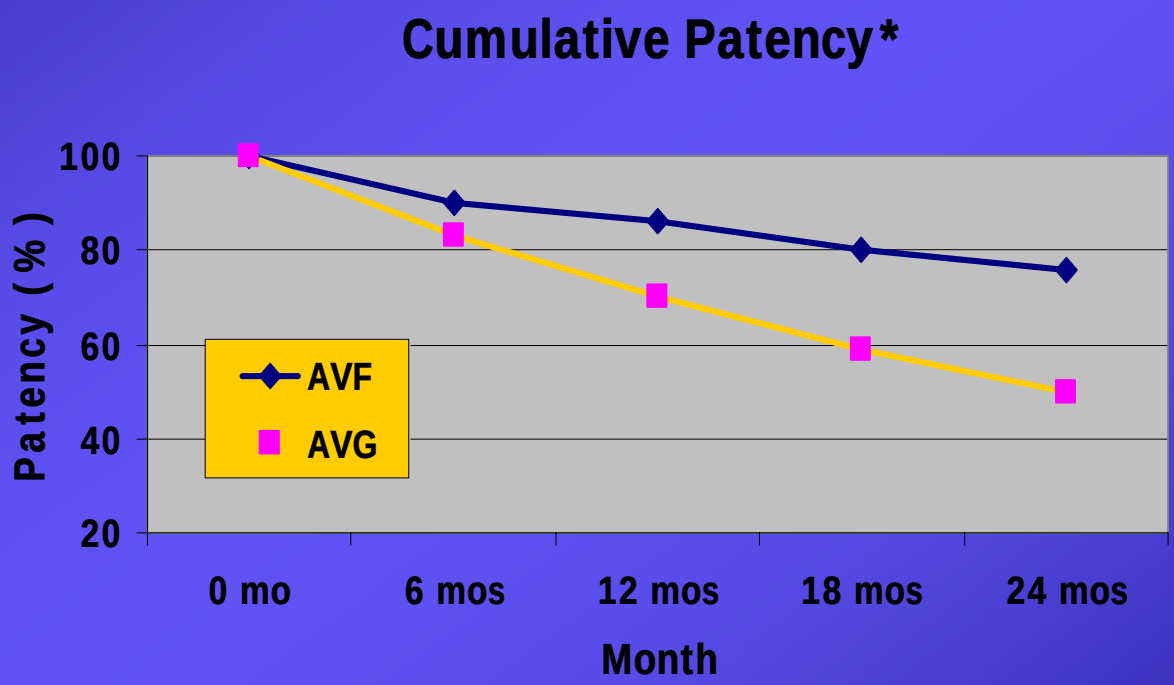


DOQI's Patency rate goal (30d):

- **Forearm straight AVG: 85%**
- **Forearm loop AVG: 90%**
- **Upper arm AVG: 95%**

Schwab, *KI*, 55, 2078, May 1999

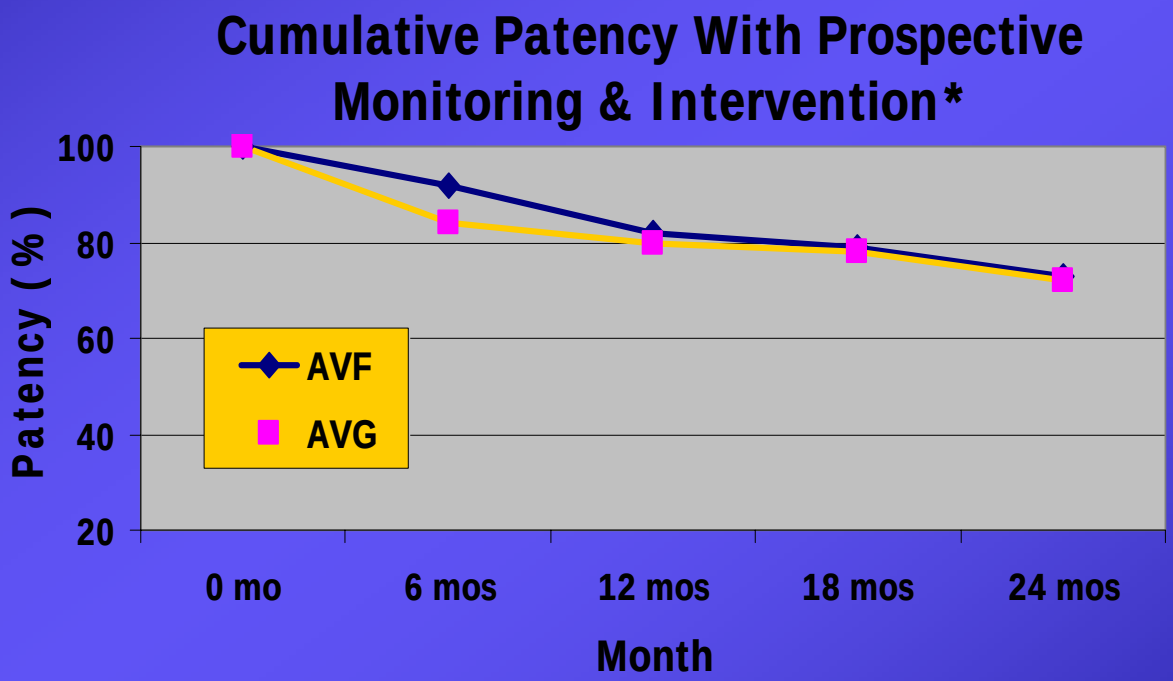
VASCULAR ACCESS OPTIONS: AVF VS AVG



*Intervention rate: AVG > 3X AVF

Schwab, *KI*, 55, 2078, May 1999

VASCULAR ACCESS OPTIONS: AVF VS AVG



*Intervention rate: AVG > 6X AVF

Schwab, *KI*, 55, 2078, May 1999

VASCULAR ACCESS: NONTHROMBOTIC COMPLICATIONS

- INFECTION
- HEART FAILURE
- ISCHEMIA AND NERVE INJURY
- ANEURYSMS AND PSEUDOANEURYSMS
- VENOUS HYPERTENSION
- SEROMA
- ACCESS IN THE LOWER EXTREMITY

INFECTION

- RESPONSIBLE FOR LOSS OF 20% OF ACCESS
- STAPH sp
- CLOTTED ACCESS
  - 20 PATIENTS WITH FEVER/SEPSIS AND + INDIUM SCANS HAD INFECTED CLOTS
  - 13/15 PATIENTS WITHOUT SYMPTOMS AND + INDIUM SCANS HAD INFECTED CLOTS
- MUPIROCIN FOR PREVENTION IN CARRIERS WITH REPEATED INFECTIONS
- 3 WEEK TREATMEN IS MINIMUM

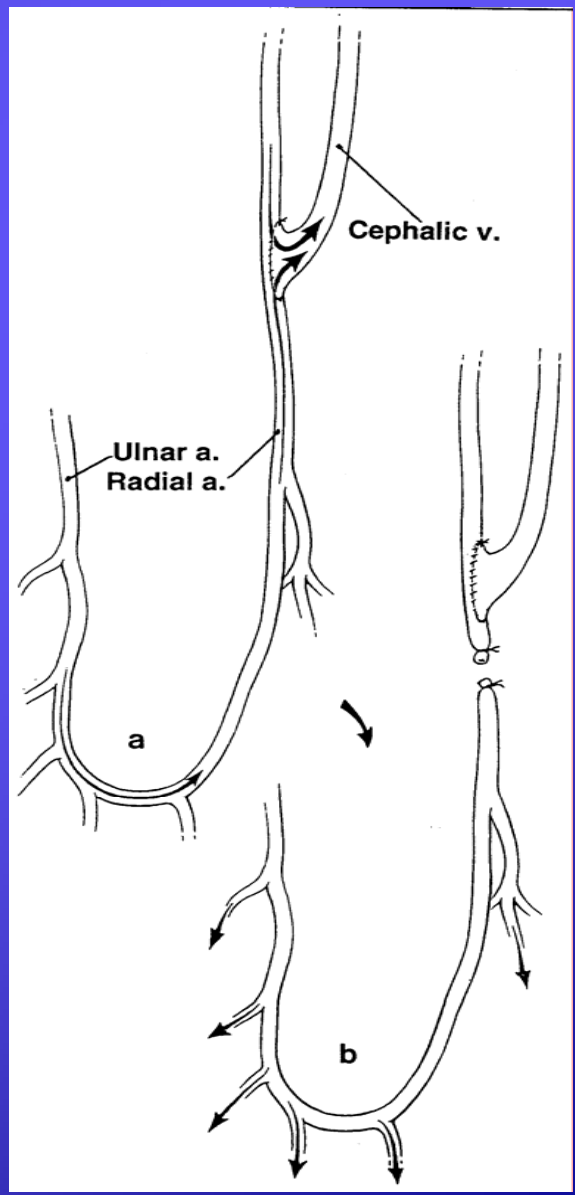
HEART FAILURE

- RISKOF HIGH OUTPUT FAILURE
  - EQUAL AVF AND PTFE ACCESS
  - LIKELY WHEN FLOW> 20% C.O.
- LVH MAY WORSEN
- BNP MAY BE USEFUL ADJUNCT TO DIAGNOSIS
- DIFFICULT TO FIX
- INDEX OF POOR LIFE EXPECTENCY

Fig. 2.21. This upper arm PAVF had an estimated 6 L/min blood flow before "banding."

ISCHEMIA

- STEAL SYNDROME
  - 1-20% INCIDENCE IN UE ACCESS
- PARESTHESIAS
- COOLNESS
- MUSCLE ATROPHY
- CLUMSINESS, LOSS OF MOTOR FUNCTION
- DISTAL NECROSIS
- THREAT OF LIMB LOSS
- REQUIRES IR OR SURGICAL INTERVENTION



ANEURYSMS AND PSEUDOANEURYSMS

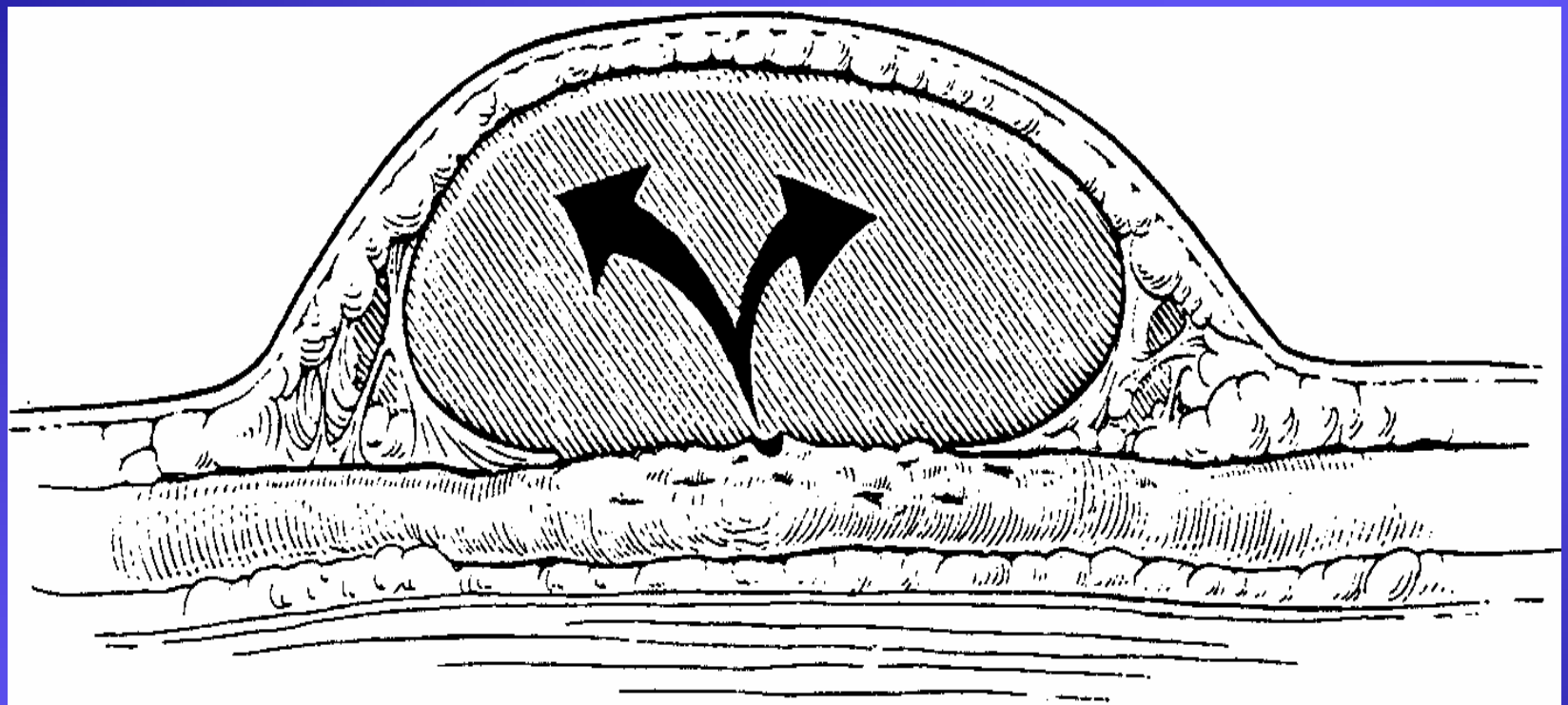
Cause/sites

- **Puncture site**
- **Accessory veins**
- **Valve**

Indication for intervention:

- **Skin overlying fistula is compromised**
- **Risk of rupture**
- **Available puncture sites limited**
- **When it involves the arterial anastomosis (DOQI)**

PSEUDOANEURYSM



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VENOUS HYPERTENSION

- INCOMPETENT VALVES OR CENTRAL STENOSIS
- EDEMA AND ULCERATION
- PRIOR IPSILATERAL CENTRAL VENOUS CATHETER
- IR OR SURGICAL CORRECTION

Fig. 2.20. Venous hypertension from PAVF usually affects the thumb and causes pain.

MEDIAL NERVE INJURY AND SEROMA

- MEDIAN NERVE INJURY
  - CARPAL TUNNEL
  - ENTRAPMENT BY HEMATOMA
  - STEAL
- SEROMA
  - LONG TERM SWELLING OVER PTFE GRAFT DUE TO EXUDATION OFPLASMA PROTEINS
  - POSSIBLE SOURCE OF INFECTION
  - ? ASSOCIATED WITH TOO EARLY USE OF GRAFT

LOWER EXTREMITY ACCESS

- 62% PATENCY @ 1 YEAR
- 50% COMPICATION RATE
  - 18% INFECTION
  - 15% ISCHEMIA
  - 6.5% ANEURYSM
  - 6.5% AMPUTATION

HEMODIALYSIS ACCCESS COMPLICATIONS

- COMPLICATIONS DUE TO ACCESS PLACEMENT PRACTICES
- COMPLICATIONS DUE TO COST
- COMPLICATIONS DUE TO MEDICAL PROBLEMS
- **INTERVENTIONS TO IMPROVE OUTCOMES**

Vascular Access Initiative: Rationale

- Vascular access is one of the most critical issues in improving dialysis quality:
  - Recent trends:
    ↓Access Patency, ↑Morbidity/ Mortality, ↑Costs
  - Attributable to:
    ↓AVF, ↑AVG, ↑Catheters
  - Access type is a major determinant of patient outcomes as well as financial outcomes
  - Most VA-related morbidity & costs due to grafts & catheters

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HOW TO INCREASE FISTULA USE

- MULTIDISCIPLINARY APPROACH TO ACCESS
- EARLY REFERRAL
- RESTRICTION OF ACCESS PROCEDURES TO INTERESTED AND EXPERIENCED SURGEONS
- ROUTINE PREOPERATIVE VASCULAR MAPPING
- EFFORTS TO SALVAGE IMMATURE FISTULAS
- ENHANCED TRAINING OF DIALYSIS STAFF

CONSEQUENCES OF LATE REFERRAL

- LATE REFERRAL DECREASES LIKELIHOOD OF PERMANENT ACCESS AT INITIATION OF DIALYSIS.
- LATE REFERRAL INCREASES DIALYSIS CATHETER USE.
- PATIENT LESS LIKELY TO HAVE FISTULA PLACED IF DIALYSIS INITIATED WITH A CATHETER.
- FISTULA SURVIVAL WORSE IF PT STARTS DIALYSIS WITH A CATHETER.

4. Surgeon Selection

Possible specific changes:

- Nephrologists refer to vascular access surgeons willing to meet specific standards and expectations
- Surgeons are evaluated on frequency, quality, and patency of access placements

ACCESS INITIATIVE

M Sekkarie, Clin Nephrol 61:2004

- PRE-PERIOD: SURGEON DRIVEN
- PERIOD 1: SURGEON EDUCATION- **CARROT**
  - NEPHROLGIST DRIVEN
  - DOQI GUIDELINES
  - LITERATURE PROVIDED
  - SURGICAL EXPERTS AVAILABLE FOR CONSULTS
- PERIOD 2: “INSISTENCE PHASE”- **STICK**
  - IGNORE LOCAL VENOUS MAPPING
  - REFER TO OTHER SURGEONS WITH SKILL
  - NEPHROLGISTS INSIST ON FISTULA CREATION
  - TRACK SURGICAL RESULTS/OUTCOME

ACCESS INITIATIVE

M Sekkarie, Clin Nephrol 61:2004

	PRE PROJECT	PERIOD 1	PERIOD 2
FISTULAE	12 (15%)	23 (27%)	36 (49%)
GRAFTS	61 (76%)	56 (66%)	28 (38%)
CATHETERS **(includes maturing AV accesses)**	7 (9%)	6 (7%)	10 (13%)
TOTAL	80 (100%)	85 (100%)	74 (100%)

5. Full Range of Appropriate Surgical Approaches

Possible specific changes:

- Surgeons utilize current techniques for AVF placement including vein transposition
- Surgeons ensure mapping is performed if suitable vein not identified on physical exam
- Surgeons work with nephrologists to plan and place secondary AVF in AV graft.

7. AVF Placement in Catheter Patients

Possible specific changes:

- Regardless of prior access (e.g. AV graft), nephrologists and surgeons evaluate all catheter patients as soon as possible for AVF
- Facility implements protocol to track patients for early removal of catheter

HIGHLIGHTS FROM THE DOQI:

- **GUIDELINE 10:**

  MONITORING AVG FOR STENOSIS

  - **PHYSICAL EXAM (QWK?)**
  - **DYNAMIC VP(200) (QWK)**
    - **>125MMHG X3 TIMES (COBE & OTHERS)**
    - **>150MMHG X3 TIMES (GAMBRO AK 10)**
  - **STATIC VP(0) (Q2WK)**
  - **RECIRCULATION (LATE PREDICTOR)**
  - **UNEXPLAINED Δ IN KT/V**
  - **ACCESS BLOOD FLOW (QA)**

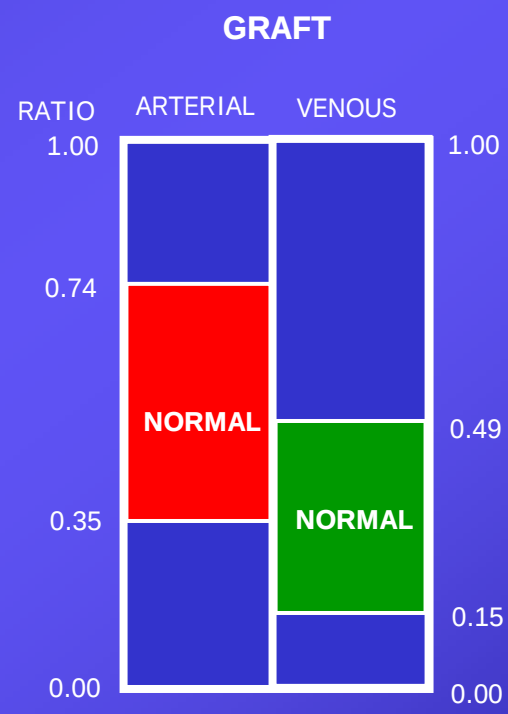
- **GUIDELINE 11:**

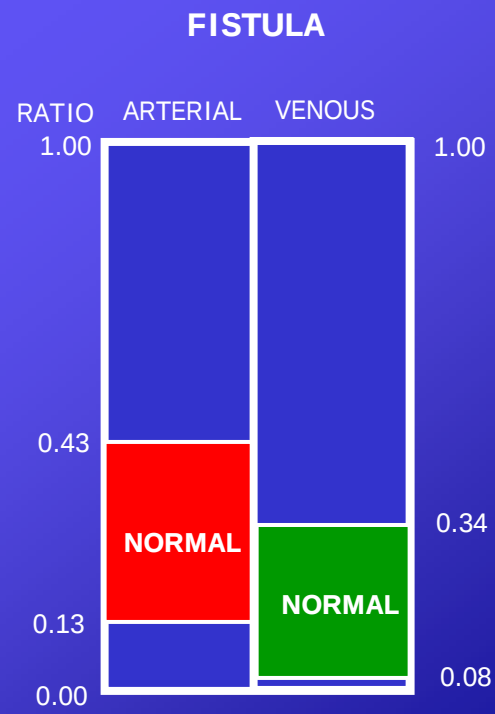
  MONITORING AVF FOR STENOSIS

  - **PHYSICAL EXAM**
  - **RECIRCULATION (+)**
  - **DOPPLER ULTRASOUND**
  - **ACCESS BLOOD FLOW**
  - **ARTERIAL PRESSURE (AP)**
  - **VP (LESS HELPFUL)**

DOQI 1997

SURVEILLANCE: STATIC VENOUS PRESSURE (ACCESS ALERT)





nVP0 = VP0 / MAP

nAP0 = AP0 / MAP

SURVEILLANCE: COLOR FLOW DOPPLER U/S

- CORRELATION OF QA WITH U/S DILUTION TECHNIQUE:

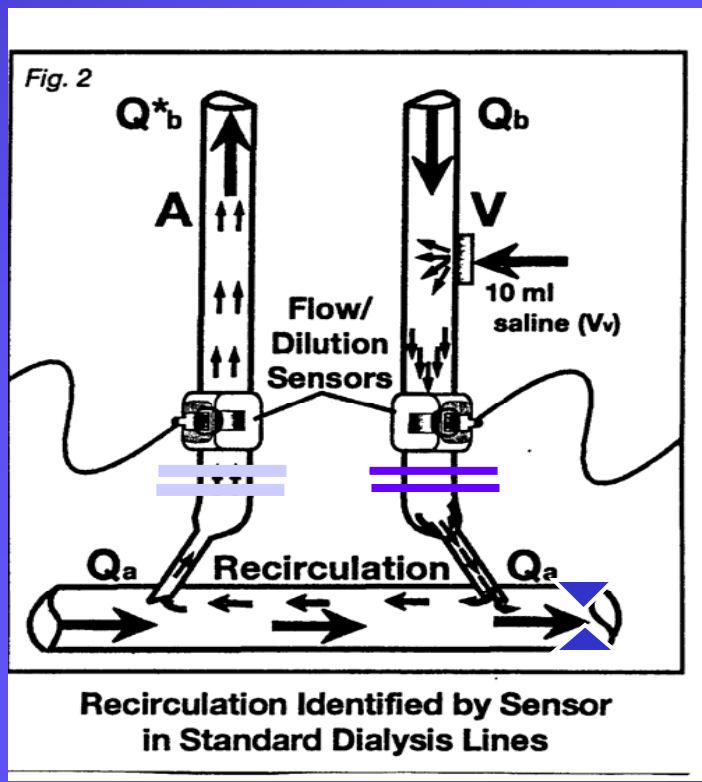
  QA(DILUTION)= 246.14 + 0.81XQA (COLOR FLOW DOPPLER)

Sands et al, *ASAIO*, 42(5):M899, 1996

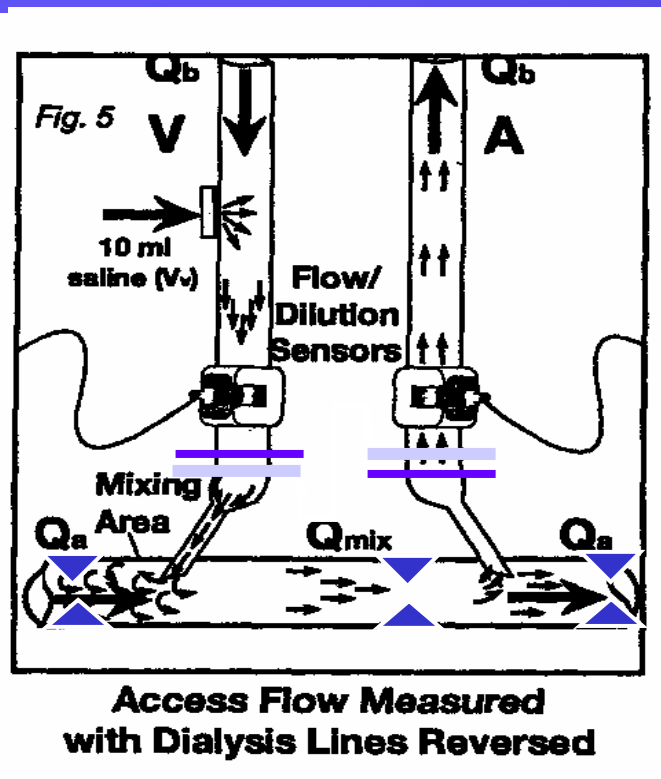
SURVEILLANCE:
U/S DILUTION TECHNIQUE (TRANSONIC)

SURVEILLANCE:
U/S DILUTION TECHNIQUE (TRANSONIC)

- **Recirculation and Access Flow Measurement:**



Recirculation Identified by Sensor in Standard Dialysis Lines



Access Flow Measured with Dialysis Lines Reversed

ACCESS FAILURE: AN EMPHASIS ON STENOSIS AND THROMBOSIS

- **The Vanderbilt experience:**
  - **Predictive measures of VA thrombosis:**

	Thrombosis	No thrombosis	p value
Sex (%) M/F	36/64	43/56	
Qa (dilution) ml/mi	875+/-426	1193+/-677	0.001
Qa (doppler) ml/mi	762+/-420	1171+/-657	0.001
VP(200) mmHg	98+/-97	97+/-25	NS
AP(200) mmHg (-)	39+/-27	42+/-21	NS
Recirculation %	4.9+/-4.8	5.2+/-4.1	NS

May et al, *KI*, 52, 1656, 1997

  - **Changes in Qa over time predicts VA thrombosis:**

    91 pts followed for 18 mos. Qa measured q6 mos.

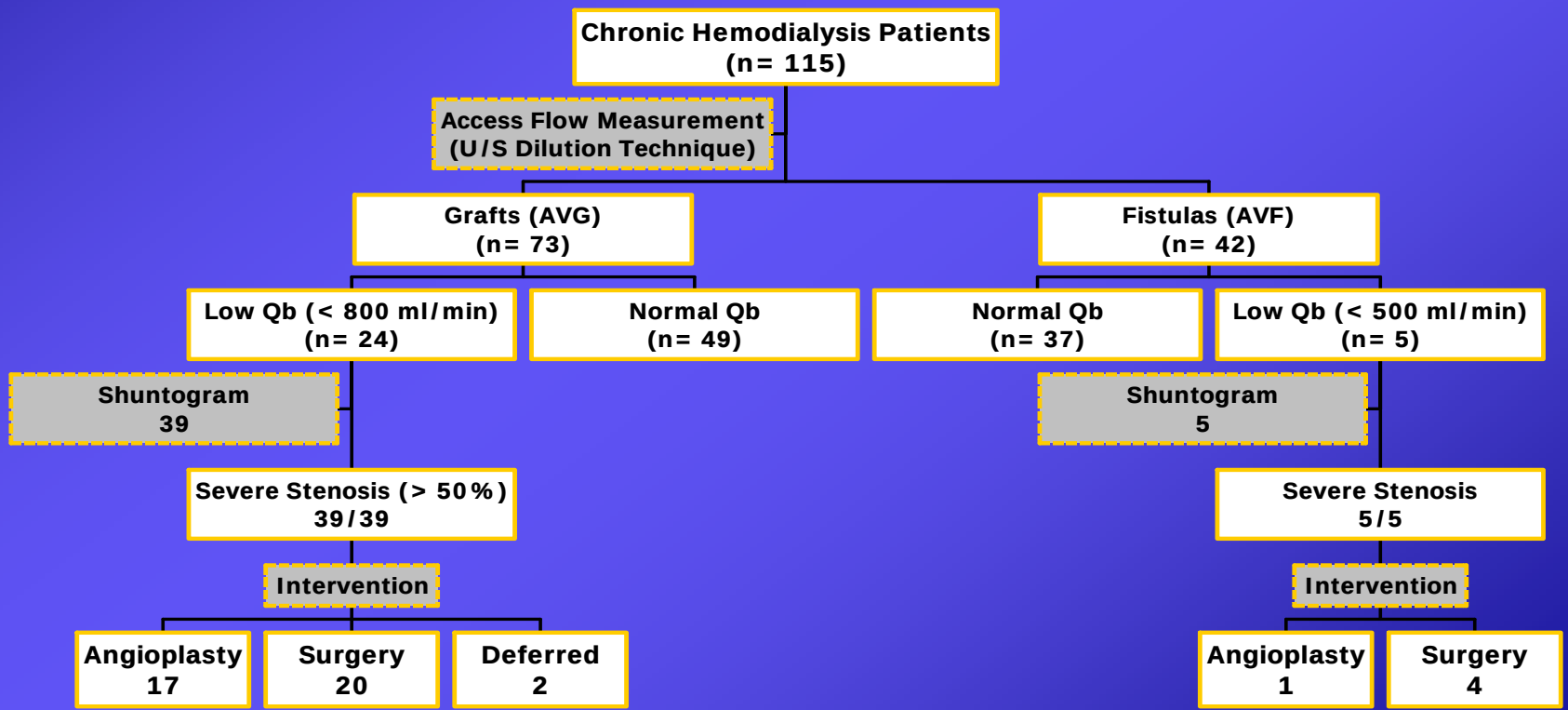
    Thrombosed accesses (34/95) had 22% and 41% ↓ in Qa in the 1st & 2nd periods respectively. (non-thrombosed had 4% & 15%↓)

    RR (thrombosis) is 13.6 fold if Qa ↓ by >35% ($p<0.01$)

Neyra et al, *KI*, 54, 1714, 1998

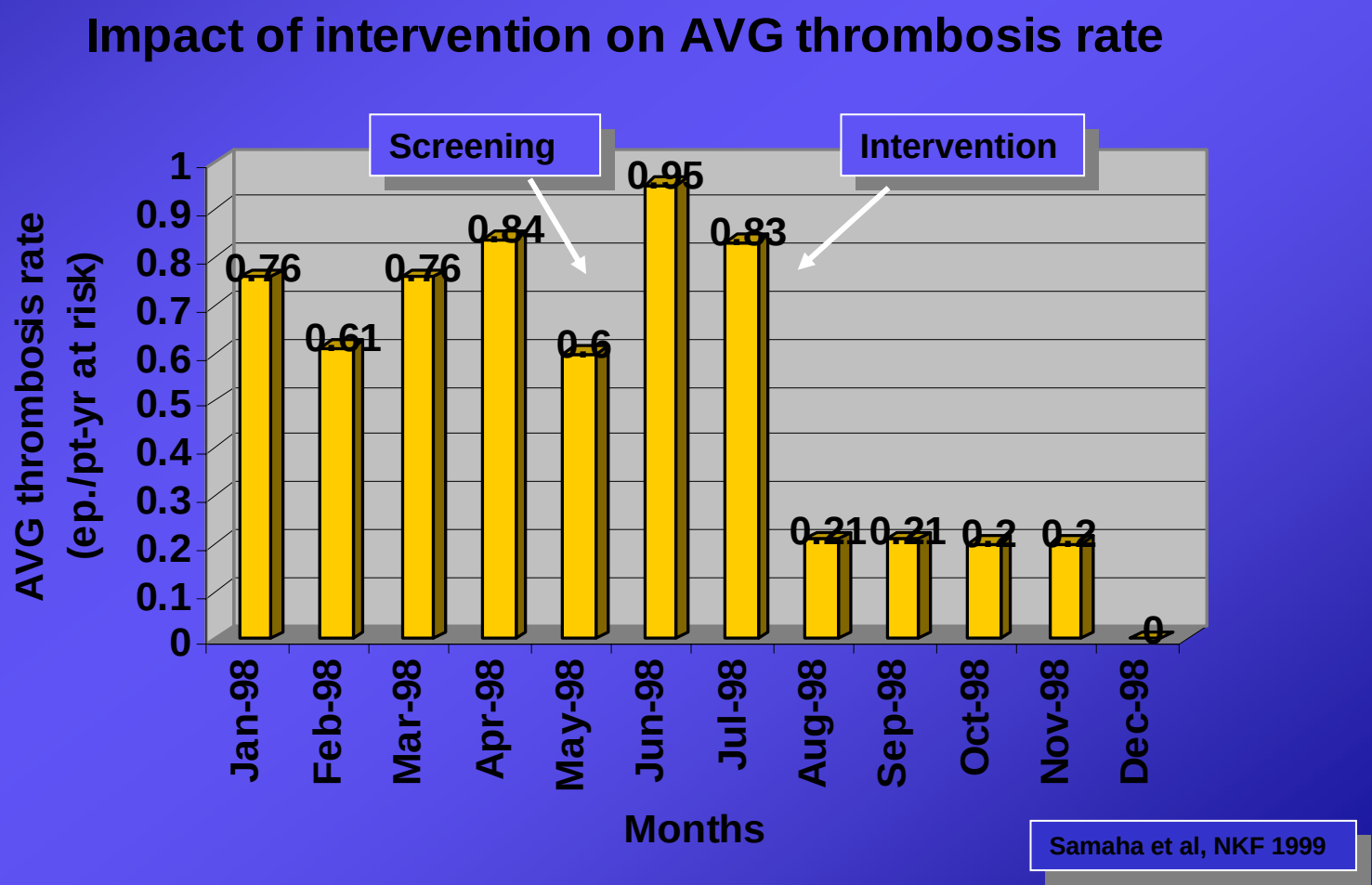
ACCESS FAILURE: AN EMPHASIS ON STENOSIS AND THROMBOSIS

- **The Vanderbilt experience (contn'd):**
  - **Impact of Qa measurement and subsequent intervention on VA thrombosis:**



Samaha et al, NKF 1999

ACCESS FAILURE: AN EMPHASIS ON STENOSIS AND THROMBOSIS



NVAII Change Concepts

1. Routine CQI review of vascular access
2. Early referral to nephrologist
3. Early referral to surgeon for “AVF only”
4. Surgeon selection
5. Full range of appropriate surgical approaches
6. Secondary AVFs in AVG patients
7. AVF placement in catheter patients
8. Cannulation training
9. Monitoring and surveillance
10. Continuing education: staff and patient
11. Outcomes feedback

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A RULE "WRITTEN IN STONE"

SAVE VEINS NAMED CEPHALIC AND BASILIC
FOR ACCESS THEY ARE NOT THROMBOPHILIC
INTO AN ABYSS OR VORTEX
HURL ALL OF YOUR GORE-TEX
AND LIFE WILL BE ALMOST IDYLLIC

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