THE ACHILLES’ HEEL OF HEMODIALYSIS: THE VASCULAR ACCESS

GERALD SCHULMAN MD
PROFESSOR OF MEDICINE
VANDERBILT UNIVERSITY SCHOOL OF MEDICINE
NASHVILLE, TN
“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-BRES西亚)
  • 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:

 Lanset
- PTFE, e-PTFE, Diastat…

 Lanset
- 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)
    - DOUBLE CHAMBER-TITANIUM RESERVOIR
HEMODIALYSIS ACCESS COMPLICATIONS

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

- COMPLICATIONS DUE TO ACCESS PLACEMENT PRACTICES
- COMPLICATIONS DUE TO COST
- COMPLICATIONS DUE TO MEDICAL PROBLEMS
- INTERVENTIONS TO IMPROVE OUTCOMES
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アクセス
- LACK OF ACCESS MONITORING PROGRAMS
FREQUENCY OF PRE-ESRD PLACEMENT OF PERMANENT DIALYSIS ACCESS IS SUB-OPTIMAL

Held, AJKD 1996, 28 (SUPPL. 2):58-78

Permanent Access Placed or Attempted Before ESRD
1,997 patients incident in 1993 (USRDS DMMS Wave 1)
INDICES OF SUB-OPTIMAL PRE-ESRD CARE LACK OF PERMANENT DIALYSIS ACCESS

IFUDU, AJ KD, 28: 841, 1996

Temporary Access for First HD

- Nephrologist: 36%
- Non-Nephrologist: 89%
- No Medical Care: 100%
## Odds of Starting HD with Permanent AV Access versus Catheter by 2 Practice Patterns

<table>
<thead>
<tr>
<th>Practice Pattern</th>
<th>Adjusted Odds Ratio (AOR)*</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seen by nephrologian &gt; 1 month prior to ESRD (yes v. no)</td>
<td>6.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>VA surgery within ≤ 2 weeks of referral (yes v. no)</td>
<td>1.8</td>
<td>0.002</td>
</tr>
</tbody>
</table>

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

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

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.

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

Without diabetes, peripheral vascular disease, and coronary artery disease

With diabetes, peripheral vascular disease, and/or coronary artery disease

**Without diabetes, peripheral vascular disease, and coronary artery disease**

- Male, age 18-54 yrs: 89 EUR, 41 US
- Female, age 18-54 yrs: 76 EUR, 22 US

**With diabetes, peripheral vascular disease, and/or coronary artery disease**

- Male, age >54 yrs: 82 EUR, 22 US
- Female, age >54 yrs: 64 EUR, 10 US

DOPPS I: 1997-98

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
Catheter Use and Outcomes
THERE ARE ONLY TWO TYPES OF CATHETERS: THOSE THAT ARE INFECTED AND THOSE THAT WILL BE INFECTED.
Catheter Use Associated with High Infection Rates

RR of Infection

<table>
<thead>
<tr>
<th>Catheter Type</th>
<th>RR</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunneled Catheters</td>
<td>5</td>
<td>p&lt;0.0001</td>
</tr>
<tr>
<td>Untunneled Catheters</td>
<td>7.8</td>
<td>p&lt;0.0001</td>
</tr>
<tr>
<td>Fistulae</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*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

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

Facility Catheter Use, % of patients

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>1.00</td>
<td>1.08</td>
<td>1.17</td>
<td>1.13</td>
<td>1.23</td>
</tr>
<tr>
<td>p</td>
<td>0.27</td>
<td>0.05</td>
<td>0.13</td>
<td>p≤0.01</td>
<td></td>
</tr>
</tbody>
</table>

(US)-10% in this group
(US)-50% in this group
HEMODIALYSIS CATHETERS

• FEMORAL CATHETERS-5 DAYS
• NONCUFFED CATHETERS- 4 WEEKS
• CATHETER DEDICATED FOR HD
• PROPER TECHNIQUE
• USE OF MUPIROCIN WHEN INDICATED
  – RESISTANCE
  – DEGRADES POLYURETHANE CATHETERS
• ANTIBIOTIC LOCK POST HD GENTAMICIN/CITRATE
HEMODIALYSIS ACCESS COMPLICATIONS

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

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

• ACCESS RELATED SPENDING (1994): ≈$1 BILLION,
  ≈$8000/PT-YR AT RISK

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

USRDS 1998
Feldman et al, JASN, 7(4): 523, 1996
## Access Procedure Rates Are Much Higher for Grafts versus Fistulae

<table>
<thead>
<tr>
<th>Type of Procedure</th>
<th>Graft</th>
<th>Fistula</th>
<th>Adjusted Relative Proc. Rate (G/F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angiogram</td>
<td>7</td>
<td>6</td>
<td>1.25</td>
</tr>
<tr>
<td>Angioplasty alone</td>
<td>8</td>
<td>4</td>
<td>1.86†</td>
</tr>
<tr>
<td>Thrombectomy, clot lysis or revision</td>
<td>59</td>
<td>17</td>
<td>3.84‡</td>
</tr>
<tr>
<td>Any VA procedure</td>
<td>74</td>
<td>28</td>
<td>2.99‡</td>
</tr>
</tbody>
</table>

†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.
ELECTIVE OUTPATIENT VASCULAR ACCESS PLACEMENT COSTS LESS

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

$10,557

$2,990

Inpatient

Outpatient

Setting of Vascular Access Placement
HEMODIALYSIS ACCESS COMPLICATIONS

- COMPLICATIONS DUE TO ACCESS PLACEMENT PRACTICES
- COMPLICATIONS DUE TO COST
- COMPLICATIONS DUE TO MEDICAL PROBLEMS
- INTERVENTIONS TO IMPROVE OUTCOMES
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 PROCEDURES REQUIRED
  – 75% 1 YR PATENCY
PATIENTS ARE INFREQUENTLY INSTRUCTED TO PROTECT THE ARM FOR VASCULAR ACCESS

HELD, AJKD 1997, 30 (SUPPL. 1)

Were You Told To Avoid Blood Draws or IV Lines Pre-ESRD?

- Yes: 36.5%
- No: 47.3%
- Not Sure: 16.2%

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)
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

VASCULAR ACCESS OPTIONS: AVF VS AVG

Primary Patency

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

Cumulative Patency*

*Intervention rate: AVG > 3X AVF

Schwab, KI, 55, 2078, May 1999
VASCULAR ACCESS OPTIONS: AVF VS AVG

Cumulative Patency With Prospective Monitoring & Intervention*

*Intervention rate: AVG > 6X AVF

Schwab, KI, 55, 2078, May 1999
FATE OF AN UPPER ARM ACCESS CREATED AFTER PRIMARY FAILURE OF A FOREARM FISTULA

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Fistulas</th>
<th>Grafts</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of patients</td>
<td>59</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Primary failures, ( n ) (%)</td>
<td>26 (44)</td>
<td>10 (20)</td>
<td>0.006</td>
</tr>
<tr>
<td>Access interventions before maturation, mean ± SD</td>
<td>0.42 ± 0.10</td>
<td>0.16 ± 0.08</td>
<td>0.04</td>
</tr>
<tr>
<td>Duration of catheter dependence, ( d )</td>
<td>131 ± 31</td>
<td>34 ± 13</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Catheter infections after sec access placement, mean ± SD</td>
<td>1.33 ± 0.29</td>
<td>0.38 ± 0.08</td>
<td>0.003</td>
</tr>
<tr>
<td>Catheter infections per 1000 catheter-days</td>
<td>3.2</td>
<td>2.6</td>
<td>0.59</td>
</tr>
<tr>
<td>Median cum acc surv (excluding primary failures), ( d )</td>
<td>1524</td>
<td>517</td>
<td>0.03</td>
</tr>
<tr>
<td>Median cum acc surv (including primary failures), ( d )</td>
<td>231</td>
<td>355</td>
<td>0.97</td>
</tr>
<tr>
<td>Median prim acc surv (excluding primary failures), ( d )</td>
<td>392</td>
<td>146</td>
<td>0.01</td>
</tr>
<tr>
<td>Median prim acc surv (including primary failures), ( d )</td>
<td>100</td>
<td>91</td>
<td>0.50</td>
</tr>
<tr>
<td>Interventions per year after access maturation</td>
<td>0.73</td>
<td>2.38</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Interventions per year from access creation to permanent failure</td>
<td>1.28</td>
<td>2.66</td>
<td>0.005</td>
</tr>
</tbody>
</table>
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 TREATMENT IS MINIMUM
<table>
<thead>
<tr>
<th>Group (n)</th>
<th>Sample type</th>
<th>Access comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter-fistula (35)</td>
<td>Incident</td>
<td>Catheters at initiation versus fistulas at 6 months</td>
</tr>
<tr>
<td>Catheter-catheter (15)</td>
<td>Incident</td>
<td>Catheters at initiation and at 6 months</td>
</tr>
<tr>
<td>Fistula-only (23)</td>
<td>Incident</td>
<td>Fistulas at initiation and 6 months</td>
</tr>
<tr>
<td>Prevalent maintenance hemodialysis (65)</td>
<td>Cross-sectional</td>
<td>Fistulas versus catheters</td>
</tr>
</tbody>
</table>
Figure 1 | C-reactive protein (CRP) levels (mg per 100 ml) decrease significantly in incident maintenance hemodialysis patients who initially dialyze with a non-infected catheter but with a fistula at 6 months ($P < 0.0001$). By contrast, no change in CRP is observed in incident maintenance hemodialysis patients who initiated dialysis with a catheter and remained with a catheter at 6 months ($P = 0.17$). CRP concentrations are shown as median (interquartile range) in the boxes.
<table>
<thead>
<tr>
<th></th>
<th>Initiation</th>
<th>6 months</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catheter-fistula</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hb (g per 100 ml)</td>
<td>10.4 ± 0.5</td>
<td>12.5 ± 0.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Alb (g per 100 ml)</td>
<td>3.4 ± 0.7</td>
<td>4.0 ± 0.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>CRP (mg per 100 ml)</td>
<td>4.3 (3.7, 5.0)</td>
<td>0.8 (8.6, 1.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>EPO dose (U/week)</td>
<td>13,425 ± 225</td>
<td>5875 ± 175</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>ERI (U/kg/(Hb))</td>
<td>537 ± 120</td>
<td>167 ± 75</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>Phosphorus (mg per 100 ml)</td>
<td>5.1 ± 1.2</td>
<td>5.0 ± 0.8</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>Catheter-catheter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hb (g per 100 ml)</td>
<td>10.1 ± 0.5</td>
<td>10.7 ± 0.5</td>
<td>0.008</td>
</tr>
<tr>
<td>Alb (g per 100 ml)</td>
<td>3.2 ± 0.2</td>
<td>3.4 ± 0.9</td>
<td>0.47</td>
</tr>
<tr>
<td>CRP (mg per 100 ml)</td>
<td>4.4 (3.8, 5.0)</td>
<td>4.9 (4.3, 5.9)</td>
<td>0.17</td>
</tr>
<tr>
<td>EPO dose (U/week)</td>
<td>14,020 ± 330</td>
<td>15,250 ± 225</td>
<td>0.42</td>
</tr>
<tr>
<td>ERI (U/kg/(Hb))</td>
<td>624 ± 180</td>
<td>675 ± 210</td>
<td>0.38</td>
</tr>
<tr>
<td>Phosphorus (mg per 100 ml)</td>
<td>5.4 ± 1.0</td>
<td>5.0 ± 0.7</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Fistula-only</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hg (g per 100 ml)</td>
<td>10.5 ± 1.5</td>
<td>12.4 ± 1.8</td>
<td>0.0002</td>
</tr>
<tr>
<td>Alb (g per 100 ml)</td>
<td>3.8 ± 0.5</td>
<td>4.0 ± 0.4</td>
<td>0.18</td>
</tr>
<tr>
<td>CRP (mg per 100 ml)</td>
<td>0.5 (0.2, 1.0)</td>
<td>0.7 (0.3, 1.8)</td>
<td>0.24*</td>
</tr>
</tbody>
</table>
### Table 4 | Demographic, laboratory, and CRP values by access type in a prevalent group of maintenance hemodialysis patients

<table>
<thead>
<tr>
<th>Access Type</th>
<th>Age (years)</th>
<th>Vintage (years)*</th>
<th>URR (%)</th>
<th>Alb (g per 100 ml)*</th>
<th>Hb (g per 100 ml)*</th>
<th>Ca (mg per 100 ml)</th>
<th>Phos (mg per 100 ml)</th>
<th>CRP (mg per 100 ml)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fistulas (44)</td>
<td>53.4 ± 11.9</td>
<td>4.6 ± 1.8</td>
<td>72.0 ± 3.3</td>
<td>4.0 ± 0.2</td>
<td>12.2 ± 0.4</td>
<td>8.9 ± 0.9</td>
<td>5.0 ± 0.6</td>
<td>0.4 (0.2,0.7)</td>
</tr>
<tr>
<td>Catheters (21)</td>
<td>51.0 ± 10.5</td>
<td>1.1 ± 0.8</td>
<td>73.0 ± 4.2</td>
<td>3.4 ± 0.3</td>
<td>10.2 ± 1.0</td>
<td>9.2 ± 0.6</td>
<td>5.2 ± 0.7</td>
<td>3.6 (1.8,6.5)</td>
</tr>
</tbody>
</table>

*Alb, albumin; Ca, calcium; CRP, C-reactive protein; Hb, hemoglobin; Phos, phosphorus; URR, urea reduction ratio.

All values mean ± s.d. except for CRP: median (IQR).

*P<0.001 for catheters versus fistulas.
Figure 2 | C-reactive protein (CRP) levels (mg per 100 ml) are significantly lower for prevalent maintenance hemodialysis patients dialyzed with a fistula versus a non-infected catheter ($P < 0.001$). CRP concentrations are shown as median (interquartile range) in the boxes.
HEART FAILURE

• RISK OF 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
VENOUS HYPERTENSION

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

• MEDIAN NERVE INJURY
  – CARPAL TUNNEL
  – ENTRAPMENT BY HEMATOMA
  – STEAL

• SEROMA
  – LONG TERM SWELLING OVER PTFE GRAFT DUE TO EXUDATION OF PLASMA 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 ACCESS COMPLICATIONS

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

<table>
<thead>
<tr>
<th></th>
<th>PRE PROJECT</th>
<th>PERIOD 1</th>
<th>PERIOD 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FISTULAE</strong></td>
<td>12 (15%)</td>
<td>23 (27%)</td>
<td>36 (49%)</td>
</tr>
<tr>
<td><strong>GRAFTS</strong></td>
<td>61 (76%)</td>
<td>56 (66%)</td>
<td>28 (38%)</td>
</tr>
<tr>
<td><strong>CATHETERS</strong></td>
<td>7 (9%)</td>
<td>6 (7%)</td>
<td>10 (13%)</td>
</tr>
<tr>
<td>(includes maturing AV accesses)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>80 (100%)</td>
<td>85 (100%)</td>
<td>74 (100%)</td>
</tr>
</tbody>
</table>
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)
PHYSICAL FINDINGS SUGGESTIVE OF STENOSIS

- ARM SWELLING
- PROLONGED ACCESS BLEEDING
- COLLATERAL VEINS
- CHANGE IN THRILL CHARACTERISTICS
Access Flow Recirculation

Extracorporeal Blood Flow
$Q_B$, ml/min

To dialyzer

From dialyzer

AV Flow, ml/min

Artery

Vein

Recirculation, %

RECIRC = P-A/P-V X 100

AV Fistula

Courtesy of B. Canaud
SURVEILLANCE: STATIC VENOUS PRESSURE (ACCESS ALERT)

GRAFT

FISTULA

\[ nVP0 = \frac{VP0}{MAP} \]
\[ nAP0 = \frac{AP0}{MAP} \]
SURVEILLANCE: COLOR FLOW DOPPLER U/S

• CORRELATION OF QA WITH U/S DILUTION TECHNIQUE:

\[ QA(\text{DILUTION}) = 246.14 + 0.81 \times QA(\text{COLOR FLOW DOPPLER}) \]

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:
ACCESS FAILURE: AN EMPHASIS ON STENOSIS AND THROMBOSIS

The Vanderbilt experience:

- Predictive measures of VA thrombosis:

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

- 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)

20% decrease or absolute graft flow of <650ml/min/ fistula flow <500ml/min

May et al, KI, 52, 1656, 1997

Neyra et al, KI, 54, 1714, 1998
The Vanderbilt experience (cont’d):

- Impact of Qa measurement and subsequent intervention on VA thrombosis:

Chronic Hemodialysis Patients (n= 115)

Access Flow Measurement (U/S Dilution Technique)

Grafts (AVG) (n= 73)

Low Qb (< 800 ml/min) (n= 24)

Shuntogram 39

Severe Stenosis (> 50%) 39/39

Intervention

Angioplasty 17

Surgery 20

Deferred 2

Normal Qb (n= 49)

Fistulas (AVF) (n= 42)

Normal Qb (n= 37)

Low Qb (< 500 ml/min) (n= 5)

Shuntogram 5

Severe Stenosis 5/5

Intervention

Angioplasty 1

Surgery 4

Samaha et al, NKF 1999
Effect of Dipyridamole plus Aspirin on Hemodialysis Graft Patency

Bradley S. Dixon, M.D., Gerald J. Beck, Ph.D., Miguel A. Vazquez, M.D., Arthur Greenberg, M.D., James A. Delmez, M.D., Michael Allon, M.D., Laura M. Dember, M.D., Jonathan Himmelfarb, M.D., Jennifer J. Gassman, Ph.D., Tom Greene, Ph.D., Milena K. Radeva, M.S., Ingemar J. Davidson, M.D., T. Alp Ikizler, M.D., Gregory L. Braden, M.D., Andrew Z. Fenves, M.D., James S. Kaufman, M.D., James R. Cotton, Jr., M.D., Kevin J. Martin, M.D., James W. McNeil, M.D., Asif Rahman, M.D., Jeffery H. Lawson, M.D., Ph.D., James F. Whiting, M.D., Bo Hu, Ph.D., Catherine M. Meyers, M.D., John W. Kusek, Ph.D., Harold I. Feldman, M.D., for the DAC Study Group

N Engl J Med
Volume 360(21):2191-2201
May 21, 2009
Study Overview

• In this randomized, double-blind, placebo-controlled trial of twice-daily extended-release dipyridamole and aspirin, used after the placement of a new arteriovenous graft, the primary outcome was loss of primary unassisted patency; secondary outcomes included cumulative graft failure and death.

• Active treatment had a significant but modest effect of reducing the risk of stenosis and improving the primary unassisted patency of newly created grafts.
Kaplan-Meier Estimates of the Cumulative Incidence of Loss of Primary Unassisted Graft Patency, According to Study Group

### Incidences of Primary and Secondary Outcomes, According to Study Group

#### Table 2. Incidences of Primary and Secondary Outcomes, According to Study Group.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Extended-Release Dipyridamole plus Aspirin (N=321)</th>
<th>Placebo (N=328)</th>
<th>Hazard Ratio [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of primary unassisted patency</td>
<td>256 (80)</td>
<td>274 (84)</td>
<td>0.82 (0.68–0.98)†</td>
</tr>
<tr>
<td>Thrombosis</td>
<td>127 (40)</td>
<td>139 (42)</td>
<td>0.84 (0.65–1.08)</td>
</tr>
<tr>
<td>With stenosis ≥50%, on angiography</td>
<td>69 (21)</td>
<td>79 (24)</td>
<td>0.74 (0.53–1.04)</td>
</tr>
<tr>
<td>With stenosis &lt;50%, on angiography</td>
<td>5 (2)</td>
<td>3 (1)</td>
<td>1.59 (0.38–6.70)</td>
</tr>
<tr>
<td>Angiography not performed</td>
<td>53 (17)</td>
<td>57 (17)</td>
<td>0.95 (0.64–1.39)</td>
</tr>
<tr>
<td><strong>Angioplasty</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenosis ≥50%, no thrombosis</td>
<td>93 (29)</td>
<td>103 (31)</td>
<td>0.70 (0.52–0.95)</td>
</tr>
<tr>
<td>Stenosis &lt;50%, no thrombosis</td>
<td>1 (0.3)</td>
<td>4 (1)</td>
<td>0.29 (0.03–2.79)</td>
</tr>
<tr>
<td>Procedure performed for infection</td>
<td>21 (7)</td>
<td>14 (4)</td>
<td>1.54 (0.75–3.17)</td>
</tr>
<tr>
<td>Procedure performed for other reason‡</td>
<td>10 (3)</td>
<td>6 (2)</td>
<td>1.75 (0.58–5.30)</td>
</tr>
<tr>
<td>Failure to use graft by wk 12 in patients with catheter for access</td>
<td>4 (1)</td>
<td>8 (2)</td>
<td>0.48 (0.14–1.59)</td>
</tr>
<tr>
<td>Stenosis ≥50%, with or without thrombosis</td>
<td>162 (50)</td>
<td>182 (55)</td>
<td>0.72 (0.57–0.90)§</td>
</tr>
<tr>
<td><strong>Secondary outcomes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cumulative graft failure</td>
<td>161 (50)</td>
<td>173 (53)</td>
<td>0.95 (0.76–1.19)</td>
</tr>
<tr>
<td>Death</td>
<td>105 (33)</td>
<td>115 (35)</td>
<td>1.00 (0.76–1.31)</td>
</tr>
<tr>
<td>Cumulative graft failure or death</td>
<td>208 (65)</td>
<td>218 (66)</td>
<td>1.01 (0.83–1.24)</td>
</tr>
</tbody>
</table>

* Data were compared between the two study groups with the use of a Cox proportional-hazards model with the prespecified adjustments for serum albumin level and use or nonuse of an angiotensin-converting–enzyme inhibitor or angiotensin-receptor blocker. The unadjusted hazard ratio for the primary outcome of loss of primary unassisted patency in the dipyridamole–aspirin group was 0.81 (95% confidence interval [CI], 0.68 to 0.97; P=0.03).  
† P=0.03.  
‡ Procedures performed for other reasons were as follows: in the dipyridamole–aspirin group, access ligation for hand ischemia (in three patients), angioplasty or access ligation for central vein stenosis (three patients), surgical revision for pseudaneurysm without stenosis (two patients), access ligation for arm edema without stenosis (one patient), and ligation for uncontrolled bleeding without angiography (one patient); and in the placebo group, access ligation for hand ischemia (in four patients), angioplasty or access ligation for central vein stenosis (one patient), and surgical revision for pseudaneurysm without stenosis (one patient).  
§ P=0.005.
Conclusion

- Treatment with dipyridamole plus aspirin had a significant but modest effect in reducing the risk of stenosis and improving the duration of primary unassisted patency of newly created grafts.
Fistula Thrombosis

<table>
<thead>
<tr>
<th>Table 2. Fistula Thrombosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. (%) of Patients</strong></td>
</tr>
<tr>
<td>Clopidogrel (n = 435)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Thrombosis at 6 wk (all patients)</td>
</tr>
<tr>
<td>By location</td>
</tr>
<tr>
<td>Forearm fistula</td>
</tr>
<tr>
<td>Upper arm fistula</td>
</tr>
</tbody>
</table>

<sup>a</sup>Six of the 441 patients randomized to clopidogrel and 5 of the 436 patients randomized to placebo were not included because patency was not evaluated.

<sup>b</sup>Relative risks were stratified for fistula location and center.

<sup>c</sup>The 95% confidence interval reported is the repeated confidence interval adjusted for interim monitoring. The repeated P value adjusted for interim monitoring is .018.

# Fistula Suitability Failure

<table>
<thead>
<tr>
<th>Table 3. Fistula Suitability Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. (%) of Patients</strong></td>
</tr>
<tr>
<td><strong>Clopidogrel (n = 385)a</strong></td>
</tr>
<tr>
<td>Suitability failure (all patients)</td>
</tr>
<tr>
<td>By location</td>
</tr>
<tr>
<td>forearm fistula</td>
</tr>
<tr>
<td>upper arm fistula</td>
</tr>
<tr>
<td>By failure reason</td>
</tr>
<tr>
<td>fistula abandoned with no expectation of future use</td>
</tr>
<tr>
<td>fistula not yet in use despite treatment with dialysis</td>
</tr>
<tr>
<td>fistula in use during ascertainment period but failed to meet suitability criteria</td>
</tr>
</tbody>
</table>

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.

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

WILLIAM J. STONE, MD
PROFESSOR OF MEDICINE
CHIEF, NEPHROLOGY SECTION, VAMC
VANDERBILT UNIVERSITY MEDICAL CENTER
THE DEATH OF ACHILLES