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ASN DIALYSIS CURRICULUM

Monitoring and Surveillance of Vascular Access

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Objectives

- Define Monitoring of vascular access and differentiate from Surveillance
- Discuss surveillance techniques
- Discuss available evidence on access assessment tools

Current Vascular Access Options

- **AV fistula and AV graft are considered superior to catheter access**
- **Remarkable success has been achieved in increasing prevalence of AV fistula**
- **However, vascular access complications are common and result in hospitalization, mortality and expense**
- **Guidelines suggest various methods to maintain patency of vascular access**

Common Issues With Vascular Access

- **Primary failure due to poor maturation of AVF**
 - ~ 60% failure rate -NIH sponsored DAC study, JAMA 2008
- **Stenosis due to neo-intimal hyperplasia in established access**
 - AVG: Mainly at the venous anastomosis
 - AVF: Arterial (inflow) anastomosis, venous (outflow) track
- **Thrombosis as a result of stenosis**
 - AVG >AVF
 - Each thrombotic event reduces the survival of the access
- **Central vein stenosis:**
 - ‘ ‘ incidence with subclavian catheters
 - ‘ with number of central catheters
 - Needs recurrent intervention to maintain patency

Definitions

Monitoring— evaluation of the vascular access by means of physical examination to detect physical signs that suggest the presence of dysfunction

Surveillance— Involves periodic evaluation of access by special tests requiring special instruments to detect dysfunction

- Access flow
- Intra access pressure and resistance
- Doppler duplex ultrasound imaging

Rationale for Access Assessment

- **Stenosis is almost always a prerequisite for access thrombosis**
- **Preemptive detection and correction of stenosis should reduce likelihood of access thrombosis**
- **Results of intervention after thrombosis of access are inferior to the results of preemptive intervention (angioplasty)**
- **Non invasive monitoring can predict such stenosis with a high positive predictive value**

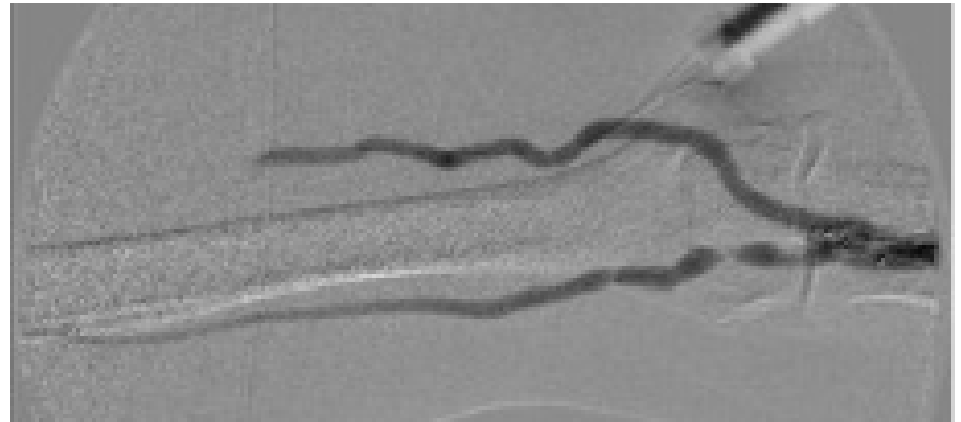
Goals of Access Assessment

- **Early detection of anatomically severe, and physiologically significant stenosis within the access**
- **To be able to correct the stenosis and prevent thrombosis- which requires diagnostic testing and intervention**

K/DOQI Clinical Practice Guideline 4 – Treatment of Stenosis

Clinical criteria

- “ Qa <600 ml/min AVG
- “Qa <500 ml/min AVF
- Elevated intra-access venous pressures
- Abnormal PE



Prospective trend analysis can detect dysfunction better compared to single test value

Potential Advantages with Access Assessment

- **Keep permanent vascular access patent**
- **Improve dialysis clearance**
- **Minimize or avoid central venous catheter use**
- **Improve Quality of Life for patients and dialysis staff**

Goals of Monitoring and Surveillance

- **New AVF**
 - Identify primary failures
 - Plan for early interventions
 - Plan for surgical revision/new access
- **Established AVF/AVG**
 - Early detection of problem to prevent
 - Thrombosis
 - Prolong patency
 - Inadequate dialysis treatment

When to Start Monitoring

- **Soon after creation of AVF to follow maturation**
- **Throughout the life of AV access (both AVF and AVG)- to maintain patency and adequate function**

Methods of Monitoring

- **Physical Examination**
 - (inspection, palpation, auscultation) to detect physical signs of dysfunction or loss of patency
- **Measurement of delivery of dialysis dose**
- **Presence of clinical evidence of dysfunction**
 - difficult cannulation, prolonged bleeding after dialysis, swelling of extremity, aneurysm formation of access

Initial Evaluation of AVF

- **To evaluate maturity and adequate flow**
- **Should be done at 4 weeks after creation**
- **Rule of 6's for 'maturity'**
 - 6mm diameter
 - 6mm or less in depth
 - 6cm straight segment for cannulation
 - 600ml/minute blood flow

Markers of an Adequate AVF

- **Fistula size >4mm has 89% chance of successful use vs. 44% if smaller in size**
- **Fistula flow >500ml has 84% chance of successful use vs. 43% if less**
- **Combining the two- 95% vs. 33% success if criteria were not met**

Sensitivity and Specificity of Monitoring (Physical Examination)

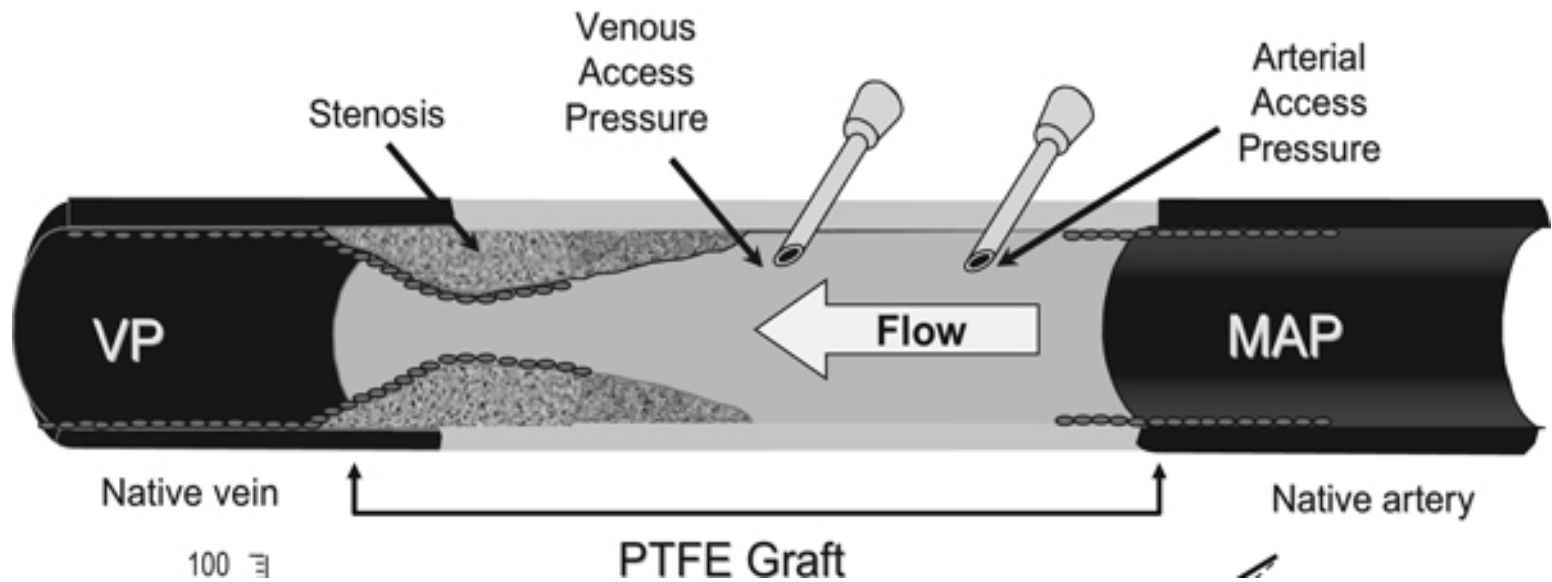
- 142 consecutive patients
- Upper arm AVF 95 (67%)
- Forearm AVF 47 (33%)

<u>Diagnosis</u>	<u>Sens</u>	<u>Spec</u>	<u>PE + Angio</u>
Inflow stenosis	85%	71%	83%
Outflow Stenosis	92%	86%	89%
Coexisting inflow-outflow stenosis	68%	84%	79%
Central vein stenosis	13%	99%	poor

Surveillance Method Selection

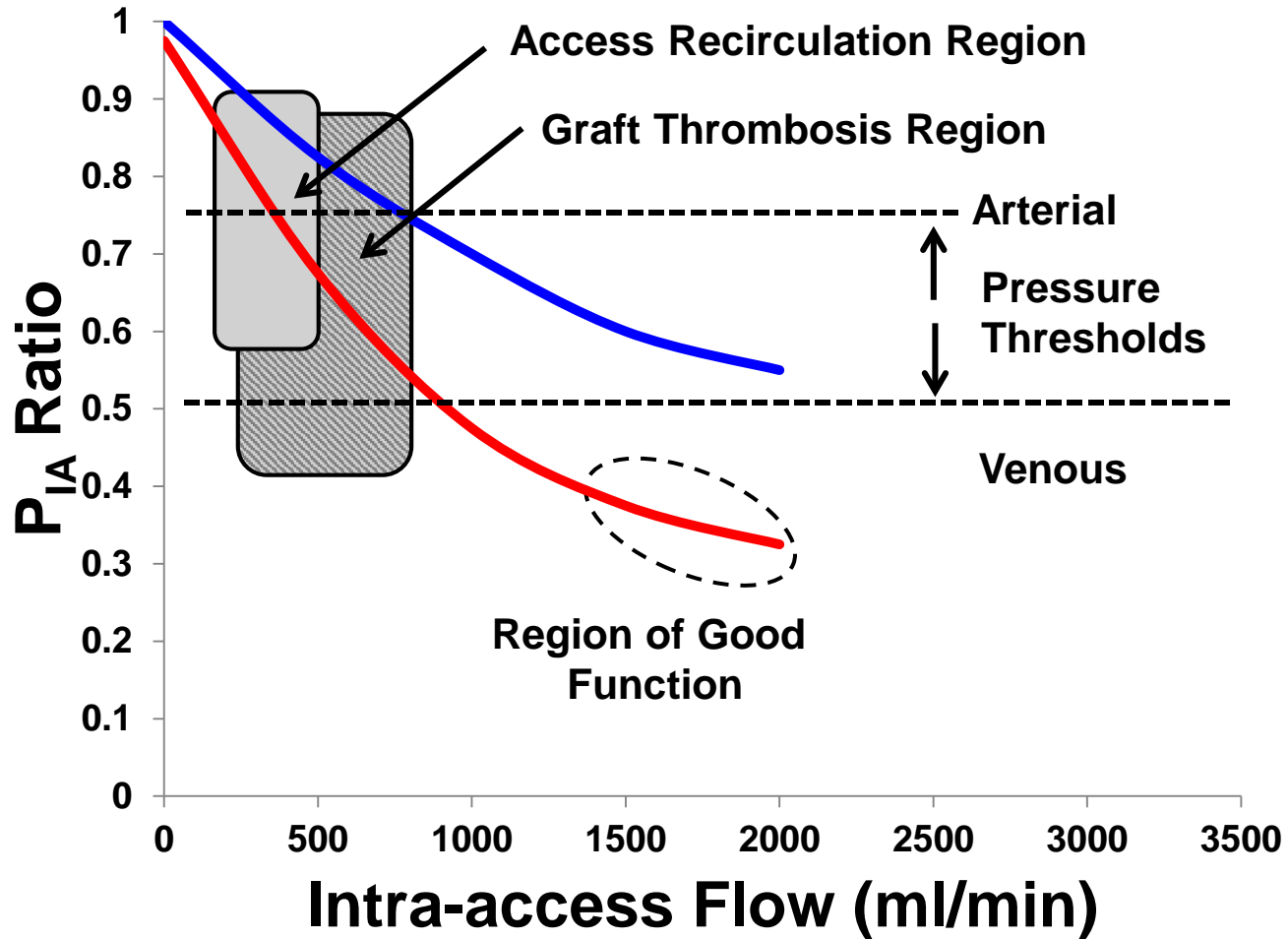
- **Ease of test**
- **Technical / labor cost**
- **Data Collection and review**
- **Evidence in literature**

Flow – Pressure Relationships



- ‘ access pressures indicates development of stenosis
- Venous access pressures can change with MAP
- $VAPR = VAP/MAP$

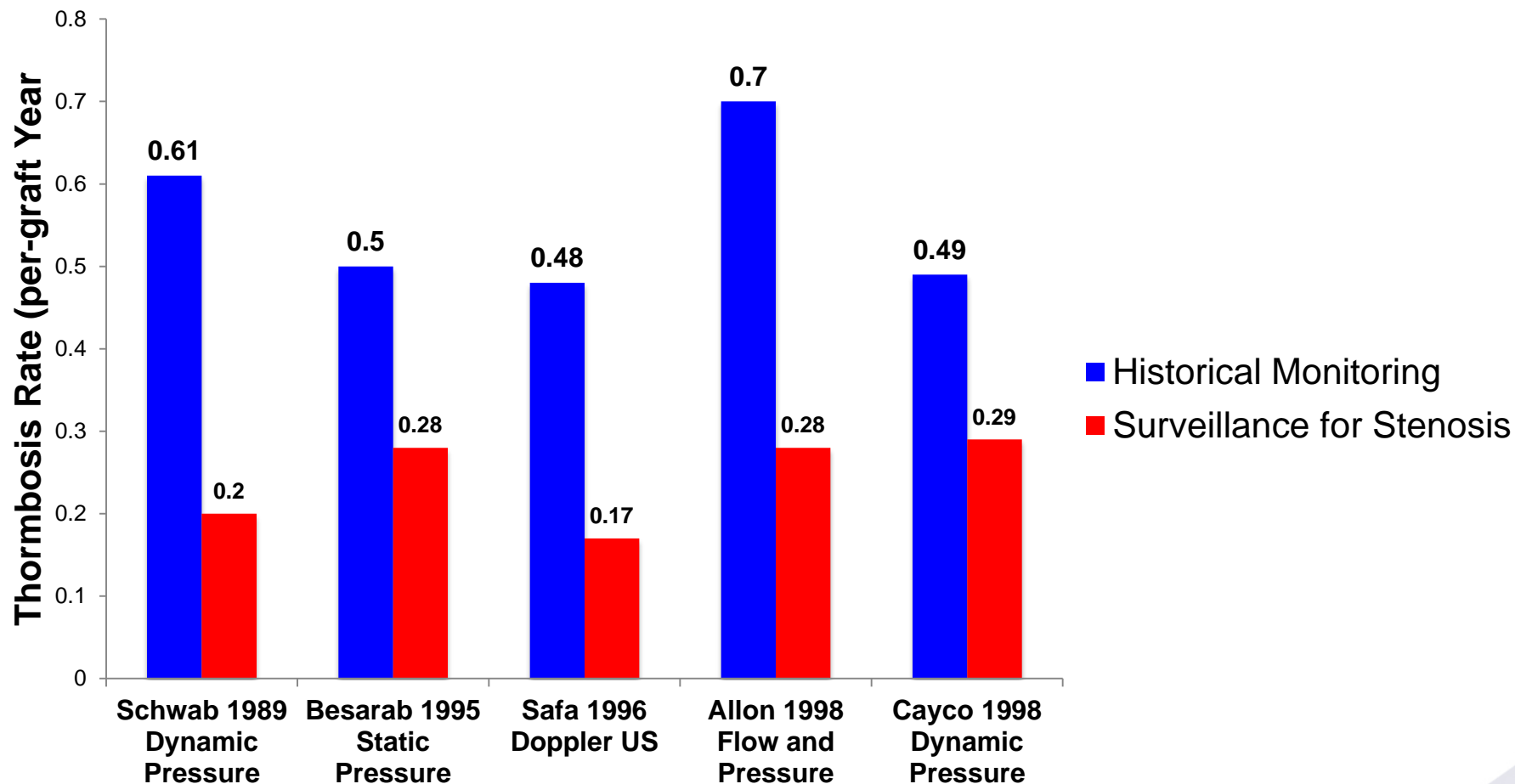
Effect of Graft Venous Outlet Stenosis



Surveillance Methods

- **Access blood flow – induced recirculation**
 - using transonic device –saline – gold standard
 - change in UF rate using hematocrit
 - change in conductance with built-in flow measurement device in a dialysis machine (Gambro, Fresenius 2008K)
- **Static venous pressures**
- **Doppler Ultrasound imaging**

Compilation of Studies using Historical Controls Showing the Effect of Surveillance vs Monitoring



Unadjusted Thrombosis-free Survival

- 5 year randomized controlled trial compared blood flow surveillance and preemptive repair of subclinical stenoses (one or both of angioplasty and open surgery) with standard monitoring and intervention based upon clinical criteria alone to determine if the former prolonged the longevity of mature forearm AVFs
- Surveillance with blood pump flow (Q_b) monitoring during dialysis sessions and quarterly shunt blood flow (Q_a) or recirculation measurements identified 79 AVFs with angiographically proven, significant ($>50\%$) stenosis
- AVFs were randomized to either a control group (intervention done in response to a decline in the delivered dialysis dose or thrombosis; $n=36$) or to a pre-emptive treatment group ($n=43$)

Unadjusted Thrombosis-free Survival

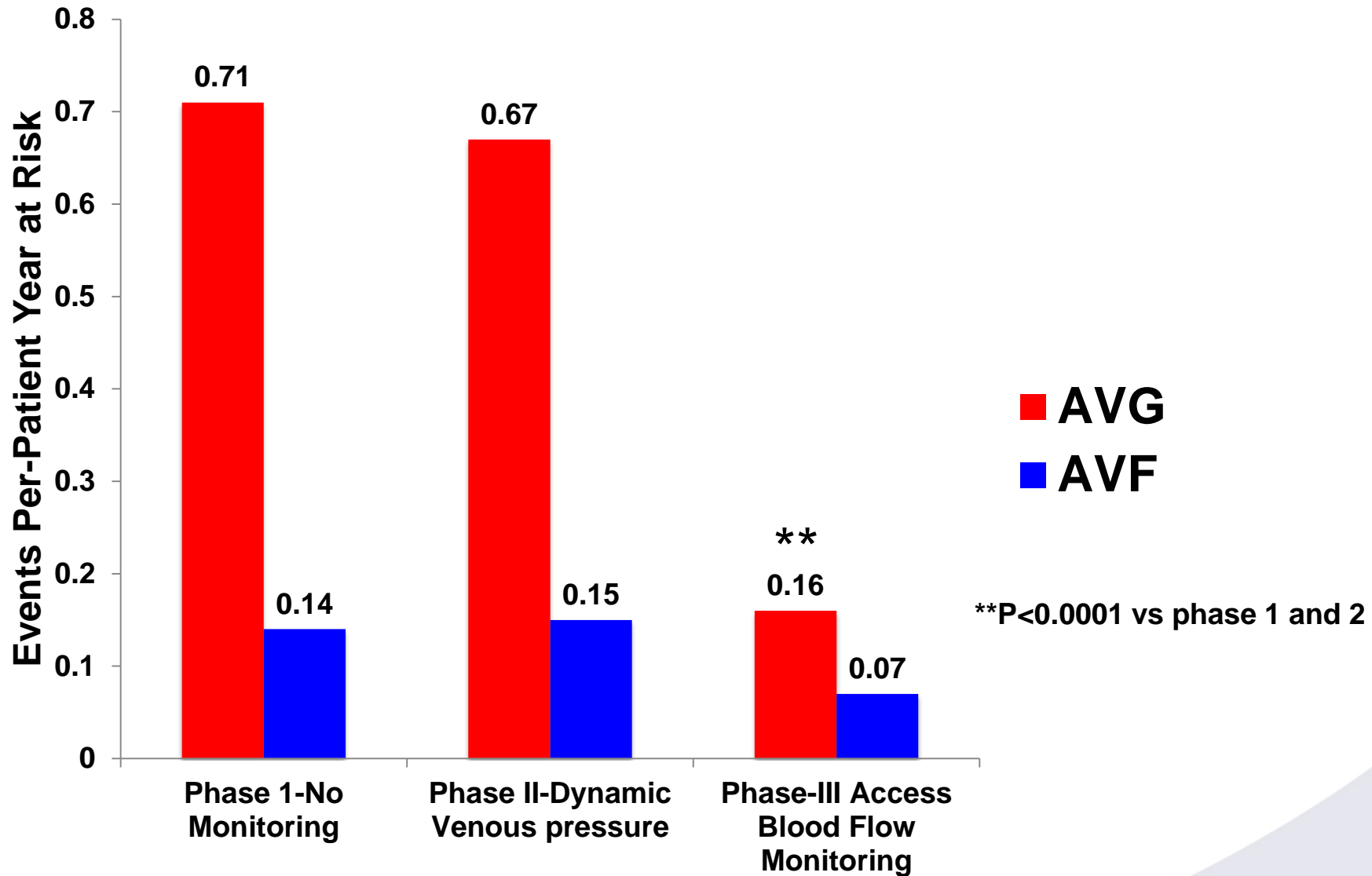
- A Kaplan–Meier analysis showed that preemptive treatment reduced failure rate ($P=0.003$) and the Cox hazards model identified treatment ($P=0.009$) and higher baseline Qa ($P. 0.001$) as the only variables associated with favourable outcome
- Primary patency rates were higher in treatment than in control AVFs in both functional ($P=0.021$) and failing subgroups ($P=0.005$).
- Access survival was significantly higher in pre-emptively treated than in control AVFs ($P=0.050$), a higher post-intervention Qa being the only variable associated with improved access longevity ($P= 0.044$).
- Secondary patency rates were similar in pre-emptively treated and control AVFs in both functional ($P= 0.059$) and failing subgroups ($P=0.394$).
- Secondary patency was also similar in functional and failing AVFs in controls ($P. 0.082$), but were higher in pre-emptively treated functional AVFs than in pre-emptively treated failing AVFs ($P. 0.033$) or in the entire control group ($P. 0.019$).



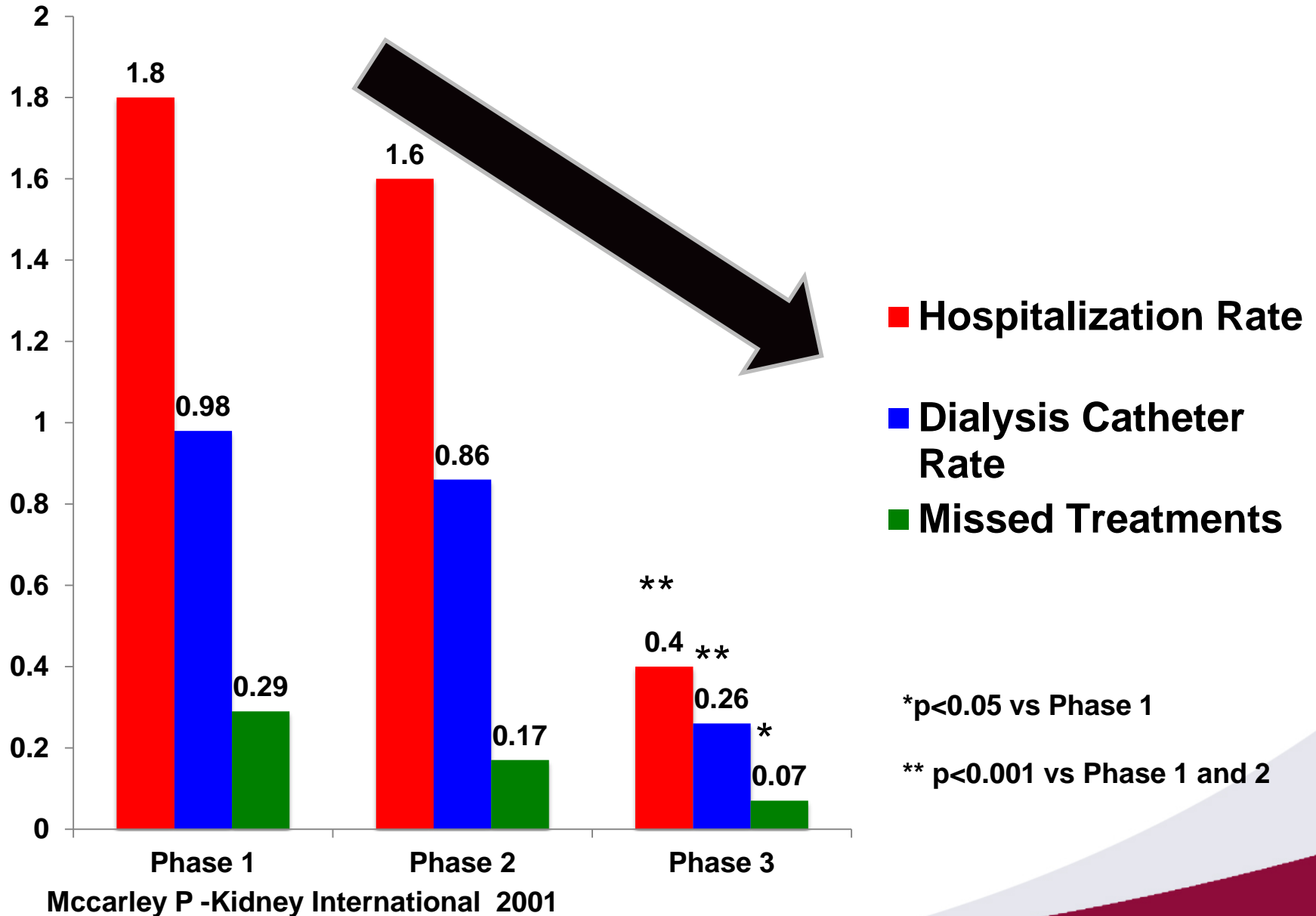
Surveillance and Access Thrombosis

- **A total of 132 chronic hemodialysis patients were treatments, and surgical interventions. Vascular access blood followed prospectively for three consecutive study phases**
 - Phase 1- 11 months of no monitoring
 - Phase 2- 12 months of dynamic venous pressure monitoring
 - Phase 3- 10 months of vascular access blood flow monitoring
- **All vascular access-related information (thrombosis rate, hospitalization, angiogram, angioplasty, access surgery, thrombectomy, catheter placement, missed treatments) collected during the three study periods**

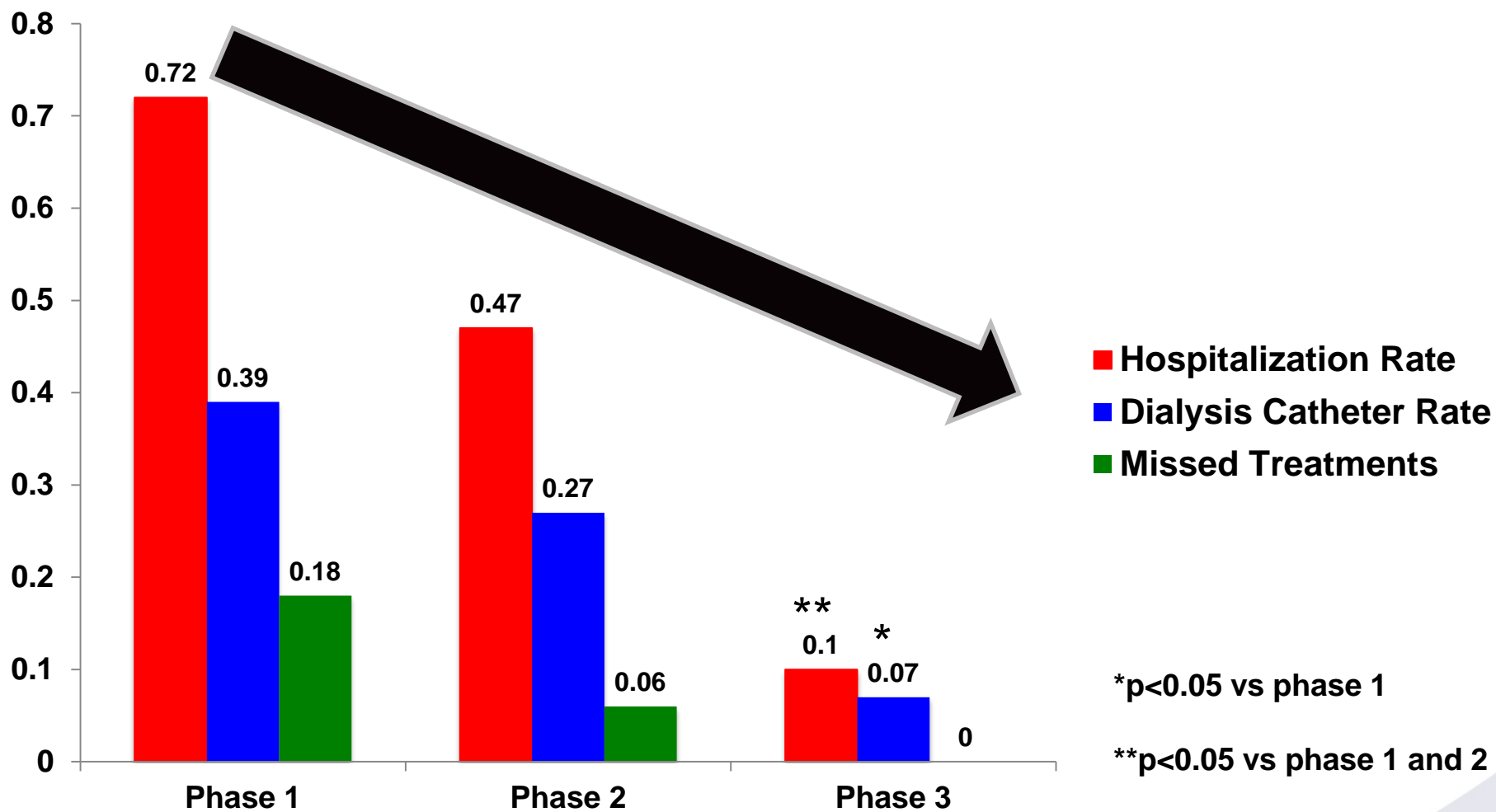
Surveillance and Access Thrombosis



Access Related Event Rates - AVG



Access related event rates - AVF

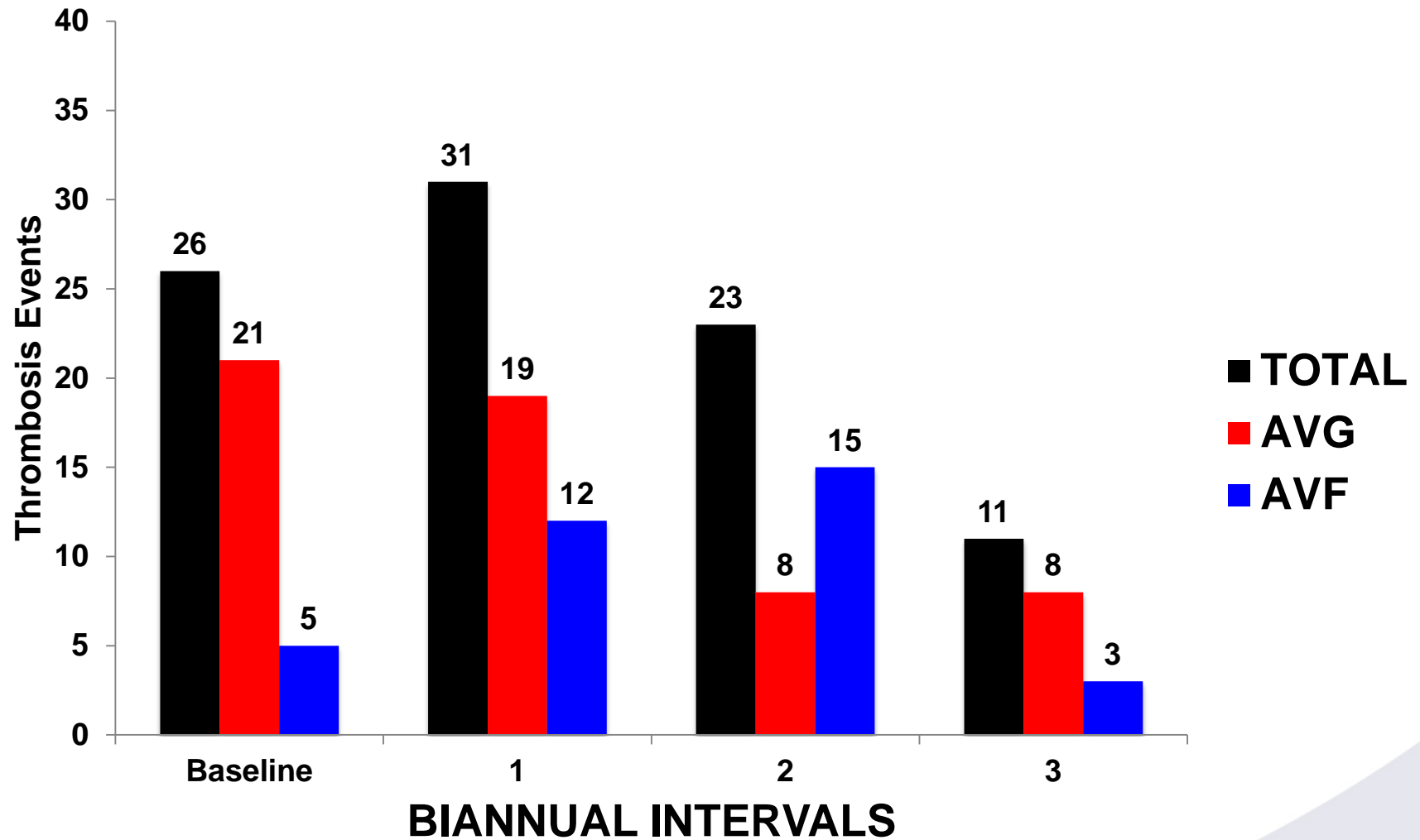


Access Pressure for Surveillance

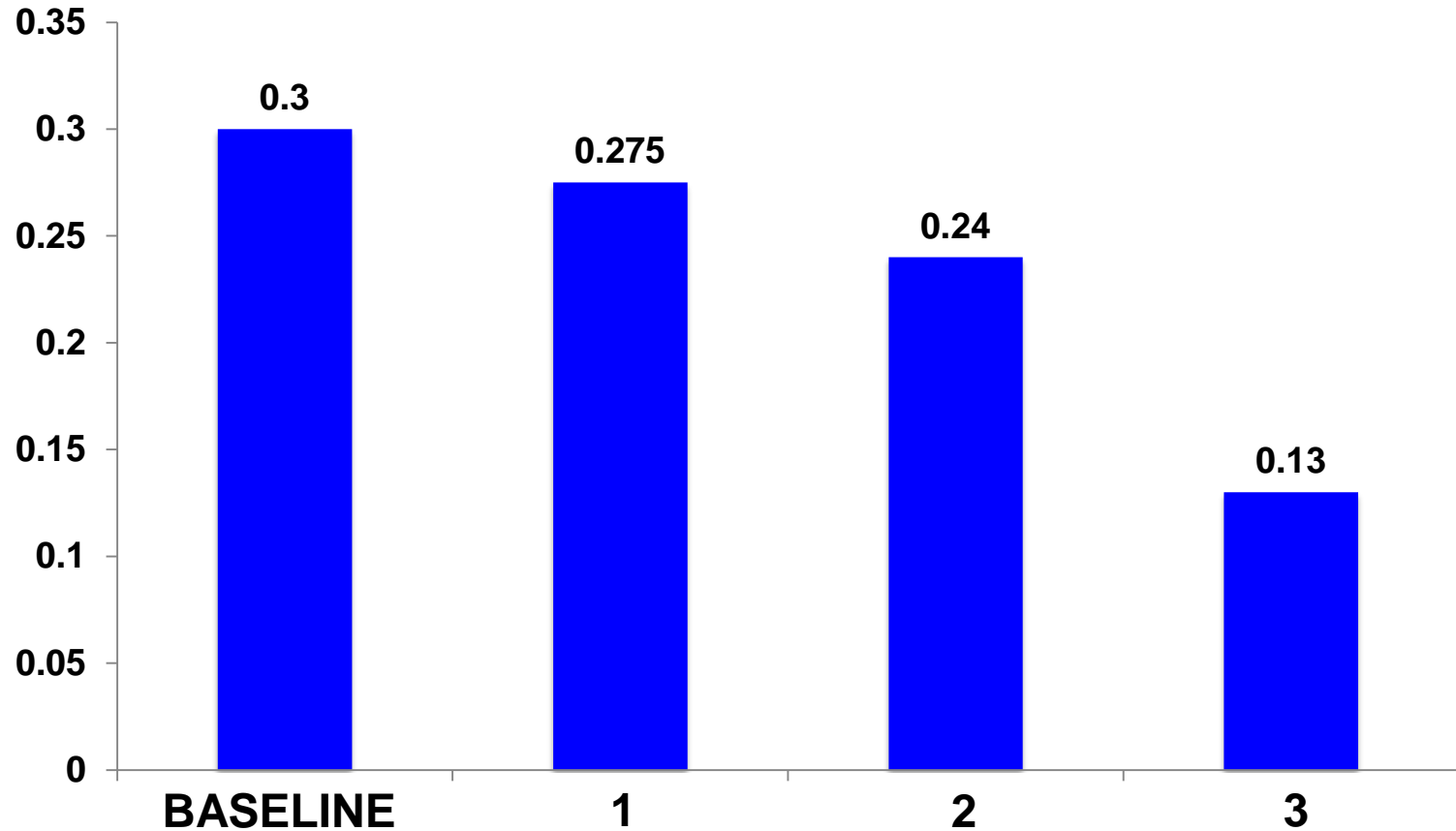
Automated non-invasive Surveillance

- **24 month study comparing thrombosis rates during a baseline 6-month interval to three subsequent 6-month periods of active surveillance**
- **Vascular access pressure ratios (VAPR) measured during each dialysis treatment**
- **Trends were monitored generating alerts**
- **VAPR > 0.55 was considered significant and referred for interventions**
- **No special instrument or technical staff was needed**
- **Thrombosis rate decreased 57% with timely intervention**

Thrombotic Events with Automation



Thrombosis Rate of Vascular Accesses



Observational Studies

- **Thrombosis rate**

- Beasarb et al (KI-1995)– 70% “ -static VP
- Sands et al (ASAIO-1999)- 6.5 fold “ -Doppler
- Hoeben et al (Am J Nep -2003)- 2-fold “ - flow surveillance
- Glazer et al (Ann Vas Surg – 2006) 2-fold “ -flow surveillance

- **Improved QOL**

- **Not necessarily prolonged the access life**

Randomized Controlled Studies

Name	Total No. of patients	Control	Study Patients	Surveillance methods tested	Primary Outcome	Results
Sands et al, 1999, ASAIO J	103	41	62	Access Flow, Static venous pressure	Access thrombosis	Positive
Moist et al, 2003, J Am Soc Nephrol	112	53	59	Access flow, dynamic venous pressure	Access thrombosis, loss	Negative
Ram et al, 2003, Am J Kidney Dis	101	34	67	Access flow, stenosis	Access thrombosis, survival	Negative
Roca-Tey et al, 2004*, Nefrologia	159	65	94	Access Flow	Access Thrombosis	Positive
Malik et al, 2005, Kidney Int.	192	92	97	Ultrasound	Cumulative patency	Positive
Plantinga et al, 2006*, J Vasc Access.	363	185	178	Multiple	Multiple outcomes	Positive
Polkinghorne et al, 2006, Nephrol Dial Transplant	126	61	65	Ultrasound	>50% stenosis	Negative
Robbin et al, 2006, Kidney Int.	126	61	65	Ultrasound	Graft survival	Negative

* Prospective nonrandomized studies

Randomized Trials with Abnormal Surveillance Results Comparing Intervention vs Observation

Name	Total no. of patients	Intervention	Observation	Surveillance methods used	Primary outcome	Result
Lumsden et al, 1997, J Vasc Surg.	64	32	32	Color flow duplex scan	Cumulative patency	Negative
Martin et al, 1999, J Vasc Interv Radiol.	21	8	13	Color flow duplex scan	Virgin graft patency	Positive
Dember et al, 2004, Kidney Int.	64	32	32	Pressure/systolic blood pressure ratio	Access survival	Negative
Tessitore et al, 2004, Nephrol Dial Transplant.	79	43	36	Access flow	Access survival, thrombosis	Positive
Scaffaro et al, 2009, J Ultrasound Med.	108	53	58	Duplex scan	Thrombosis	Negative

Drawbacks of Randomized Trials

- **Total 12 RCT, 8 AVG and 4 AVF**
- **Small sample size**
- **Population characteristics are not uniform**
- **Variable method of surveillance**
- **Recruitment criteria and randomization is unclear and not uniform**
- **Primary end point studied is variable**

Summary

- **AV access become dysfunctional due to occurrence of stenosis**
- **Clinical monitoring, primarily through evidence of access dysfunction and physical examination can provide clues to the presence of stenosis**
- **Monitoring alone is relatively inexpensive and accurate in experienced hands**

Summary

- **Conflicting results from observational and RCT studies**
- **Surveillance works in reducing thrombotic events**
- **Surveillance works in reducing hospitalization, CVC and missed HD treatment rates**
- **No definite evidence to suggest that it prolongs access life**
- **Need adequately powered RCT with a larger sample size**

Final Take Home Message

- **Monitoring and surveillance are to be used in combination to achieve the ultimate goal of maintaining access patency**
- **When done by expert staff on a routine basis, monitoring itself may be sufficient in detecting stenosis, potentially making added surveillance redundant**