Access Flow Monitoring Is Worthwhile and Valuable\textsuperscript{1}

A vascular access is a hemodialysis patient’s link to life. It is also the Achilles heel of hemodialysis, for the consequences of a thrombosed or failing vascular access are dire. In order for hemodialysis to continue, the access must be either repaired, another created, or have a central venous catheter introduced to deliver dialysis.

Transonic® ultrasound dilution technology has revolutionized vascular access patency management by enabling routine monitoring to detect decreasing access flows that preage access thrombosis failure.\textsuperscript{3-7} An impressive body of evidence, with more than 75 scientific peer-reviewed publications, supports the value of trending vascular access flow to detect clinically significant stenoses and prevent thromboses. The National Kidney Foundation’s Kidney Dialysis Outcomes Quality Initiative (KDOQI) Guidelines, European Guidelines and Australian CARI Guidelines for Vascular Access all have included guidance that addresses access trending.\textsuperscript{3,8,9}

Nevertheless, access trending detractors continue to challenge its value. They cite over and over again a few clinical trials that indicate that prevention of thrombosis through access trending and prophylactic intervention ultimately does not prolong the life of an access.\textsuperscript{10-15} These studies must be viewed within the context of the entire body of vascular access literature that concludes that access monitoring is valuable and worthwhile for the clinic, the nephrologist, the healthcare system and, most important, the patient who will experience less morbidity and fewer emergent thrombolytic events. The body of scientific literature reporting routine vascular access trending to predict the onset of stenosis in the vascular access of ESRD patients includes the following supportive studies that attest to the value of vascular access trending coupled with early intervention to reduce the thrombosis rate in both fistulas and grafts:

**Aragoncillo Study**\textsuperscript{2}

In a three-year follow-up randomized, controlled, multicenter trial of 207 patients that compared QA-based surveillance and preemptive repair of subclinical stenosis with standard monitoring techniques in prevalent mature AVFs, clinicians observed:

- A significant reduction in the thrombosis rate in the flow monitoring group versus the control group.
- A significant improvement in the thrombosis-free patency rate and in the secondary patency rate in the flow group, with no differences in the primary patency rate between the groups.
- A greater need for a central venous catheter and more hospitalizations associated with vascular access in the control group than in the flow monitoring group.
- Total vascular access-related costs were higher in the control group.

The study concludes, “QA-based surveillance combining Doppler ultrasound and ultrasound dilution reduces the frequency of thrombosis, is cost effective, and improves thrombosis free and secondary patency in autologous AVF.”

**Tessitore Study**\textsuperscript{16}

Dr. Tessitore’s 2008 study in Nephrology Dialysis and Transplantation, “Adding access blood flow trending to clinical monitoring reduces thrombosis rates and costs, and improves fistula patency in the short term: a controlled cohort study,” concludes, “Our 5-year controlled cohort study shows that adding Qa trending to monitoring in mature AVFs is associated with a better detection and elective treatment of stenosis, and lower thrombosis rates and access-related costs, although the cumulative access patency was only extended in the first 3 years after fistula maturation.”

**Wijnen Study**\textsuperscript{17}

Dr. Wijnen reports in his study “Impact of a quality improvement programme based on vascular access flow monitoring on costs, access occlusion and access failure,” that: “A quality improvement programme based on periodical access flow measurement reduced the number of acute vascular access failures due to thrombotic events and also significantly reduced health care costs in patients with AVG, but not in patients with AVF.”

**McCarley Study**\textsuperscript{5}

The Aragoncillo, Tessitore and Wijnen studies support the findings of the landmark 2001 Vanderbilt study published in Kidney International “Vascular Access Blood Flow Monitoring Reduces Access Morbidity and Costs,” that concluded that vascular access blood flow measurement (VABFM) for early detection of vascular access malfunction coupled with preventive intervention reduces thrombosis rates in both polytetrafluoroethylene grafts and native AVFs.

While there was a significant increase in the number of angioplasties performed during the flow monitoring phase, the comprehensive cost was markedly reduced due to the decreased number of hospitalizations, catheters placed, missed treatments, and surgical interventions. Vascular access blood flow monitoring along with preventive interventions should be the standard of care in chronic hemodialysis patients.” McCarley et al showed a reduction in overall costs for access-related morbidity of approximately 50% with flow trending and early intervention policies coupled with a reduction in thrombosis rates of 4.5 fold in AV grafts and 2-fold in AV fistulas.
Chaudhury, Spergel and Ravani’s recent appraisal, “The native
Contributing to this continuing dialogue Drs. Besarab, Asif, Roy-
•  When a test indicates the presence of a functionally signifi-
•  The difference between clinical “monitoring” by physical
•  The scope of the problem in maintaining patency
have undergone trending is a worthy goal of trending and reduces
They assert that a reduction in thrombotic events in patients who
“Most of the available evidence suggests that detection of ste-
Citing 86 references in their critique, they unequivocally conclude:
•  In most cases, angioplasty should be performed is the steno-
sis is greater than 50% by diameter.
•  Stenotic lesions should not be repaired simply because they
The review concludes that most of the available evidence suggests
that detection of stenosis and prevention of thrombosis in AV fis-
tulas is valuable.

Garland Review
Dr. Garland reviewed the available evidence in her 2002 report
“Are hemodialysis access flow measurements by ultrasound
dilution the standard of care for access surveillance?” published
in Advances in Renal Replacement Therapy and suggested, “that
access flow measurements are the best tests currently available to
screen for access dysfunction, and as preventative interventions,
such as angioplasty and surgery, are successful, they should be
regarded as the present standard of care. This would appear to
be a cost-effective strategy. Furthermore, the method of choice for
access flow measurement is by ultrasound dilution technology.”

Tonelli Review
Dr. Tonelli’s 2008 review of the literature “Ultrasound Monitoring
to Detect Access Stenosis in Hemodialysis Patients: A Systematic
Review,” published in the American Journal of Kidney Disease also
sought to clarify the conflicting conclusions of various randomized
trials. They examined 12 randomized controlled trials, including
four fistula studies, from a total of 1,613 citations and abstracts.
These included 69 full articles using access flow or ultrasound
screening. A total of 1,164 patients of various access types were
analyzed, 141 with fistulas. Tonelli’s group reported that:
•  Access type was significantly associated with risk of thrombosis
•  In fistula studies, access monitoring deceased risk of thrombo-
sis, but not fistula loss.
•  In graft studies, access monitoring did not reduce risk of throm-
bosis, or access loss.
Their analysis indicated that access monitoring does reduce throm-
bosis in fistula patients, but may not reduce fistula loss or extent
of resource use (cost and hospitalizations).

Vascular Access Monitoring

Studies That Challenge Vascular Access Monitoring
Reports that have challenged the value of vascular access moni-
toring include two papers9,10 that attest to the success of flow
monitoring in predicting stenosis even though the results of the
subsequent PTA interventions were disappointing. Others that have
arrived at similar conclusions have not rigorously followed the
2006 KQODI Guidelines13-15 in their access protocols.

Why Should We Bother with Access Flow Monitoring?
One must keep in mind that a few skeptical studies from a few
select centers do not represent the definitive answer, but are part of
an on-going conversation in the nephrology community on the
value of vascular access monitoring. Several have review the litera-
ture on the subject. They include the following:

Besarab Review
Contribution to this continuing dialogue Drs. Besarab, Asif, Roy-
Chaudhury, Spergel and Ravani’s recent appraisal, “The native
arteriovenous fistula in 2007. Surveillance and Monitoring,” in the
Journal of Nephrology.
At the outset the authors state, “Adequate vascular access func-
tion is the most important determinant in the success or failure of
hemodialytic therapy. Low blood flow rates and loss of patency limit
dialysis delivery, extend treatment times and result in underdialysis
leading to increased morbidity and mortality.”

Citing 86 references in their critique, they unequivocally conclude:
“Most of the available evidence suggests that detection of ste-
nosis and prevention of thrombosis in AV fistulas is valuable.”
They assert that a reduction in thrombotic events in patients who
have undergone trending is a worthy goal of trending and reduces
patient morbidity. The review defines:
•  The scope of the problem in maintaining patentcy
•  The difference between clinical “monitoring” by physical
examination and “trending” by methods such as pressure
monitoring, indicator dilution, Duplex ultrasound.
•  When a test indicates the presence of a functionally signifi-
cant stenosis, venography of fistulography should be per-
formed to definitely establish the presence and degree of the
stenosis.

2019 KDOQI Guidelines for Monitoring
AV Grafts and Fistulas
The 2019 KDOQI Vascular Access Guidelines call for an “End-Stage
Kidney Disease Life-Plan” (an individualized and comprehensive
map for dialysis modalities and vascular access for the lifetime of
the patient).
•  Primary in the Life Plan is to have a regular physical examina-
tion or check of an AVF or AVG in every patient by an experi-
enced health practitioner in order to detect clinical indicators
of flow dysfunction in the AVF or AVG.
•  If clinical indicators of flow dysfunction present, they can be
corroborated and quantified in true mL/min to remove any
reasonable doubt by Transonic HDD03 flow monitoring and
trending of vascular access flow data.
However, the authors caution that the overall quality of the trials they analyzed was "poor to moderate." Secondly, they sound the clarion call for properly conducted clinical studies to determine the optimal means to do access trending and advise that studies be separated by access type and advise that a trial of 850 fistula patients (rather than the 141 total used in this study) would be required for an adequate study.

**Valliant Review**

In their 2015 review, "Vascular Access Monitoring and Surveillance: An Update," from the Division of Nephrology, University of Wisconsin Hospitals and Clinics, Madison, WI, Valliant et al stated, "Access surveillance is increasingly important to preserve vascular access in our patients. Having another data point can help guide decision making regarding care and referral of these patients at risk for significant access dysfunction, particularly when staff are not comfortable with their ability to reliably predict access dysfunction based on physical examination alone."

**Krivitski Review**

In 2007, Krivitski presented his analysis of current vascular access literature at the European Dialysis and Transplant Association. In "Access Flow Surveillance - Major Criteria for Success," Krivitski defines three major influences on trending outcomes. They are: 1) Technology used for routine trending (access flow, intra access pressure); 2) Guidelines for referring patient for fistulography or PTA; 3) Outcome of PTA invention to improve access flow. All 26 flow publications suggest that, if a patient is referred for fistulography based on small blood flow or decreased blood flow, a hemodynamically significant stenosis (greater than 50% stenosis) exists in these vascular accesses with a positive predictive value of 92-100%. He points out that, "while all agree that there is always a high prevalence of a 50% stenosis in both grafts and fistulas, the actual definition of a hemodynamically significant stenosis is, in fact, a decrease in blood flow."

The review concludes that the main reasons for unsuccessful trending outcomes in some randomized trials were: 1) failure to use two flow thresholds to predict hemodynamically significant stenoses; when one static threshold is used, a thrombotic event can be missed. 2) Failure of PTA invention to improve access flow.

**Summary**

The value of vascular access trending has and continues to ignite a spirited debate in the nephrology community - one that is essential to the process of scientific discovery that ultimately produces improvements in diagnostic care. At this time, there is robust scientific evidence that supports vascular access trending with Transonic access flow measurements being the reference Gold Standard.

As more randomized controlled trials, such as Aragocillo’s, are conducted and their findings published that confirm the clear benefits of vascular access management through both physical examination supplemented by flow trending, it is hoped that vascular access monitoring will be universally accepted as valuable and worthwhile by the dialysis community.

**Why Prevention of Fistula Thrombosis through Access Monitoring Is Worthwhile**

A thrombosed vascular access is problematic for:

- **Dialysis Staff** who need to:
  - Assist patient in coping
  - Arrange for transportation
  - Interface between patient and physicians
  - Rearrange dialysis schedule

- **Nephrologist** who needs to:
  - Console unhappy patient & family
  - Arrange logistics to resolve AVF failure

- **Patient** who copes with:
  - Discomfort, pain, anxiety and fear
  - Delay of dialysis
  - Concerns about K+ and fluid
  - Disruption to schedule
  - Decreased quality of life


**Flow-QC®: The Cornerstone of My Vascular Access Program**

_Lawrence M. Spergel, MD FACS_

1. Measurement of True Delivered Blood Flow (Qb) vs. pump setting
   - Identify Qb disparity / avoid under-dialysis
   - If disparity is significant, provides method for identifying cause (blood pump calibration vs. inflow restriction/excessive pre-pump negative xarterial pressure)

2. Test Calibration of Blood Pump

3. Assessment of Access Function (AVF, AVG) / identify failing access (avoid underdialysis/thrombosis):
   - Access Flow (Qa); Access Recirculation; Value of absolute measurements and trend analysis (KDOQI)

4. Assessment of Catheter Function: Delivered Blood Flow; Recirculation

5. Identification of patients with Non-anatomic vs. Anatomic Cause of Access Failure (i.e. hypotension, “hypercoagulable state,” overzealous compression of cannulation sites)

6. Identification of Appropriate Blood Pump Setting for low flow access when it is not feasible to increase access flow (match blood pump setting/Qb with access flow to avoid recirculation/under-dialysis)

7. Immediate Exclusion of Access Dysfunction as cause of under-dialysis

8. Identification of inadvertent Reversal of Dialysis Lines (prevent recirculation/under dialysis)

9. Identification of Mid-access Obstruction

10. Identification of High-flow Accesses likely to cause high-output failure or limb ischemia (steal syndrome)

11. Evaluation of Options for Steal Syndrome
    - Identification of high-flow vs low flow accesses / permits selection of ideal treatment option (flow-restricting vs. re-vascularization procedure)

12. Assessment of Effectiveness of Interventions

13. Cardiac Output measurement to detect cardiac overload.
References