ion, we need to apply the energy, ingenuity, and commitment of the Fistula First Breakthrough Initiative to make sure all patients receive the vascular access that best suits their KRT goals. In addition, we need to be aware that 31% of patients with an AVF or AVG did not have their access routinely monitored for the presence of stenosis during the 2005 three-month study period. If this percentage were to be considered a surrogate for the potential access preservation we could achieve with access awareness monitoring and surveillance, it would indeed be an excellent opportunity for us to improve patient outcomes once the best vascular access has been created/placed.

* An incident patient is defined as a patient initiating in-center hemodialysis on or between Jan. 1, 2005, and Aug. 31, 2005.

** Prevalent percent is the number of a particular access type divided by all adult in-center hemodialysis patients on their last hemodialysis session during October–December 2005

*** Chronic catheter is defined as use of a catheter access continuously for 90 days or longer.

Reference

National Kidney Foundation. KDOQI Clinical Practice Guidelines for Vascular Access: Update 2006. *American Journal of Kidney Diseases*, 48(1), S176-S307, 2006

Surveillance techniques: Mathematical model shows frequent testing needed during graft surveillance

—William D. Paulson, MD

Two recent studies [1,2] have shed new light on the fundamental physics underlying the two main methods of hemodialysis synthetic graft surveillance—blood flow and dialysis venous pressure (VP) measurements. These studies are important because they provide insights that may help improve surveillance outcomes.

In reality, blood flow and VP are two sides of the same coin: As stenosis progresses, flow decreases and pressure increases. By applying basic fluid dynamics to the graft circuit, the authors showed how the two methods are impacted by the diameters of the inflow artery and outflow vein.

We studied the impact of artery and vein diameters on blood flow and VP [1,2] using duplex ultrasound to determine the diameters of arteries and veins of 94 patients. We then applied a mathematical model of the graft circuit that took into account the diameter measurements along with a number of other variables, such as hematocrit and mean arterial pressure (MAP). We found that the relative diameters of the artery and vein vary widely, but that in most patients the artery is narrower than the vein. This difference in diameters has a major impact on graft surveillance.

The first study[1] evaluated the effect of luminal diameters on the efficacy of flow surveillance. We found that the flow versus stenosis curve is sigmoid in shape (see Fig. 1), so that as stenosis progresses, flow is initially unchanged but then rapidly decreases. Moreover, a narrower artery increases flow resistance. This resistance causes an initially lower flow, with a longer delay followed by a more rapid reduction in flow as critical stenosis is reached. The dashed line shows a decrease in Q of 25% (the National Kidney Foundation's Kidney Disease Outcomes Quality Improvement referral threshold). The

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Figure 1. Flow vs. Stenosis

As the artery becomes narrower (lower artery/vein ratio), the sigmoid curve shifts to the right. This promotes delay and then rapid reduction in flow. Low, median, and high artery/vein ratios were determined from 94 patients (low and high ratios enclose 95% of patients). Circles labeled "A" and "V" represent relative diameters of arteries and veins. Values below dotted line represent decrease in Q of >25% (KDOQI referral threshold).

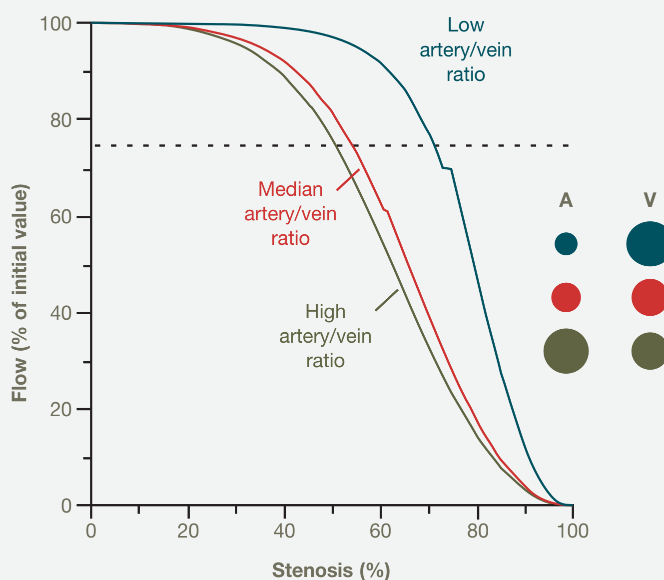
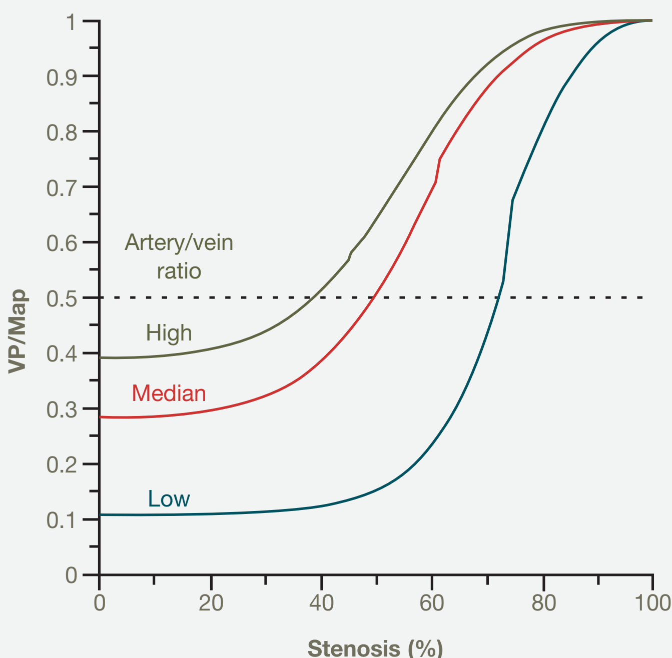


Figure 2. VP vs. Stenosis

Predicted relation between VP/MAP and stenosis at high, median, and low artery/vein ratios. Dotted line indicates static VP/MAP = 0.50 (standard KDOQI referral threshold).



> The major implication of these two studies is that the current standard of monthly or even twice monthly surveillance measurements is inadequate.

decrease in Q will not be greater than 25% until stenosis is greater than 51%, 54%, and 71%, for high, median, and low artery/vein diameter ratios, respectively. By the time the KDOQI threshold is reached, Q is on the most rapidly falling portion of the sigmoid curve, and the curve is steepest for ratios below the median.

These results predict that if flow measurements are performed only monthly, critical stenosis can be reached and thrombosis may occur before the next flow measurement is taken. This helps to explain why monthly flow measurements often fail to warn of thrombosis.

We concluded that during flow surveillance, measurements might need to be done "at least weekly" in order to detect stenosis before thrombosis occurs.

Our second study[2] determined the impact of artery and vein diameters on the ability of VP to detect stenosis. The conclusion was similar to the previous study in that a relatively narrow artery has a large impact on VP surveillance. Their model predicts that a relatively narrow artery obscures progressive stenosis until critical stenosis is reached (see Fig. 2). VP then rapidly increases and thrombosis occurs. It follows that VP shares the same challenge as flow when patients have relatively narrow arteries. However, this phenomenon is mitigated because it is relatively easy to obtain pressure readings with every treatment, thus increasing the ability to identify the increase in VP before thrombosis.

We made additional observations concerning VP: [2]

- VP/MAP is a valid adjustment for the influence of MAP on VP.
- The referral thresholds commonly used for VP (0.50 for static VP and 0.55 for derived static VP) are valid indicators that warn of a transition to critical stenosis. However, trend analysis is more important than any single measurement.
- Each graft has a unique specific relationship between VP and blood flow.

Neither study determined whether preemptive angioplasty is an effective treatment once VP or flow has detected progressive stenosis. The major implication of these two studies is that the current standard of monthly or even twice monthly surveillance measurements is inadequate. Rather, very frequent measurements are necessary in order to avoid any delay in detecting rapid increases in VP or decreases in flow. The authors hope that application of the principles described in these two studies will help improve surveillance outcomes.

References

1. White JJ et al. Influence of luminal diameters on flow surveillance of hemodialysis grafts: Insights from a mathematical model. *Clin J Am Soc Nephrol* 1: 972-978, 2006
2. White JJ et al. Mathematical model demonstrates influence of luminal diameters on venous pressure surveillance. *Clin J Am Soc Nephrol* 2: 681-687, 2007

Readers respond

This new section of Vascular Access Update will pose questions to *NN&I* readers dealing with access management issues.

This month's question:

Do you see a marked difference in patency rates between patients with AV fistulas and those with PTFE grafts in your clinic? Which access has the best rate?

Send your responses to VA Update editor Cindy Roberts, RN, CNN at cinrobrnr@netscape.net.