Balloon Angioplasty Maturation of Arteriovenous Fistulae: A New Technique to Facilitate Placement and Utilization of Primary Arteriovenous Fistulae

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A paradigm shift toward preferential placement of arteriovenous fistulae (AVFs) in patients with end-stage renal disease (ESRD) has been a primary goal of the National Kidney Foundation's Dialysis Outcomes Quality Improvement Initiative (NKF-DOQI). DOQI guidelines have led to recommendations for a greater than 50% placement of AVFs for primary access in incident patients. However, DOQI guidelines have focused more on patient selection, diagnostic evaluation, and preference of location for placement of AVFs with little or no technical advances to facilitate their primary goal. A new technique, "balloon angioplasty maturation" (BAM), provides a technique to increase the utilization of primary AVFs. BAM is a technique of staged, sequential balloon angioplasties of long segments of the venous outflow tract of AFVs. These small diameter undiseased segments are sequentially dilated up to 8 to 12 mm in diameter. The purpose of BAM is to (1) increase the utilization of small otherwise unusable veins for AVFs, (2) allow for increased utilization of wrist radial-cephalic primary AVFs, (3) shorten maturation times and indwelling catheter times, (4) improve blood flow, (5) facilitate AVF cannulation, (6) improve the lifespan of AVFs.

The technique of BAM for AVFs is that of "staged sequential dilatation" of the entire usable length of the AVF in addition to the inflow and outflow of the fistula. Serial BAMs are performed approximately 2 to 4 weeks apart with a goal of increasing the diameter of the AVF approximately 2 to 3 mm per procedure. The goal of serial BAMs was to increase the diameter of usable segments of the AVFs up to 8 to 10 mm for Brescia-Cimino AVFs, and up to 10 to 12 mm diameter for upper arm cephalic AVFs. Two additional components of BAMs are that of "flow rerouting" and "limited controlled extravasation.""Flow rerouting" is defined as balloon maturation of a primary venous channel that results in atrophy of secondary channels. This is analogous to surgical ligation of secondary veins to allow maturation of the main venous outflow. Flow rerouting is mostly utilized in forearm AVFs to divert outflow through the median cubital vein into the basilic system. This provides for a more stable and durable outflow compared to the cephalic vein as an outflow for Brescia-Cimino AVFs. Maturation of venous outflows can be performed on veins that are 2 mm or smaller, even if secondary veins are larger. This provides for selective maturation of AVF outflows that are more likely to maintain longer patencies. "Limited controlled extravasation" is the result of localized disruptions in the vein wall that heal over the course of "staged sequential dilatations." This has been documented on sequential fistulography. Extravasation is controlled by manual compression of the fistula during balloon deflation to reduce the sudden increase in pressure at the angioplasty site. Additionally, gradual sequential dilatations (usually no more than 2 mm per session) have reduced the incidence and severity of extravasations.

Two hundred eighty-eight BAMs were performed in 126 patients from July 1, 2004, until July 1, 2005. In approximately 80% of cases, patients were referred for small fistulae that were dysfunctional because they were technically unusable. The remaining 20% were primarily performed to facilitate and shorten maturation times. Fourteen patients (11.1%) underwent a single BAM. Thirty-two patients (25.4%) underwent two staged BAMs from 2 to 4 weeks apart. Seventy-two patients (57.1%) underwent three staged BAMS and 8 patients (6.4%) underwent four staged BAMs. The location of the AVF was wrist Brescia-Cimino (54.5%), upper arm cephalic vein-brachial artery (42.5%), and transposed basilic vein (3.0%). Technical success was 98.6% (four acute occlusions). The length of BAMs averaged 19.1 cm for Brescia-Cimino AVFs and 19.9 cm for upper arm cephalic vein AVFs (Table 1). BAMs increase AVF diameters ranging from 1.4 to 4.0 ◊ original diameter for Brescia-Cimino AVFs and 1.5 to 3.3 ◊ original diameter for upper arm cephalic AVFs. Follow-up of patients for up to 1 year has resulted in a primary patency of over 90%. There has been no pseudoaneurysm formation in AVFs that have undergone BAMs.

BAM maturation of AVFs is a new concept and procedure that facilitates the utilization of AVFs and increases the ability to utilize smaller veins in forearm and upper arm locations for AVFs. This technique provides surgeons with the capability to exceed DOQI recommendations of 50% primary fistula placement for incident patients undergoing hemodialysis. Fistulae are matured quicker with the theoretical advantages of shorter indwelling catheter times, increased blood flow and prolonged patencies. Larger-diameter fistulae (up to 4 times baseline diameter) facilitate cannulation and theoretically may reduce cannulation related complications such as extravasation and pseudoaneurysm formation.

BAM of AVFs encompasses percutaneous interventional techniques and new concepts of staged sequential dilatation, flow rerouting, and limited controlled extravasation. Technical considerations and methodology for these techniques are presented.

Table 1. Study Results

	Brescia-Cimono AVFs	Upper-Arm Cephalic AVFs	p Value
Number of patients	72	54	-
Initial AVF diameter (mm)	4.2 ± 1.4	5.8 ± 1.1	< .001
Initial diameter range (mm)	2.0 - 7.0	3.0 - 8.0	-
Post-BAM diameter range (mm)	8.0 - 10.0	10.0 - 12.0	-
Length of BAM (cm)	19.1 ± 6.7	19.9 ± 5.7	-
Median length of BAM (cm)	20	20	-
Range of BAM length (cm)	5.0 - 45.0	5.0 - 35.0	-