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The effect of location and configuration on forearm and upper arm hemodialysis arteriovenous grafts

Alik Farber, MD,[a] Tze-Woei Tan, MD,[b] Bo Hu, PhD,[c] Laura M. Dember, MD,[d] Gerald J. Beck, PhD,[c] Bradley S. Dixon, MD,[e] John W. Kusek, PhD,[f] and **Harold I. Feldman, MD, MSCE,[d,g] for the Dialysis Access Consortium (DAC) Study Group,*** *Boston, Mass; Shreveport, La; Cleveland, Ohio; Philadelphia, Pa; Iowa City, Iowa; and Bethesda, Md*

Objective: **The arteriovenous graft (AVG) is most often used in hemodialysis patients when an autogenous fistula is not feasible. The optimal location (forearm or upper arm) and configuration (loop or straight) of AVGs are not known. To evaluate relationships of AVG location and configuration with patency, we conducted a secondary analysis using data from a randomized, placebo-controlled trial of dipyridamole plus aspirin for newly placed AVG.**

Methods: **Participants of the Dialysis Access Consortium (DAC) Graft Study with newly placed upper extremity prosthetic grafts involving the brachial artery were studied. Multivariable analyses adjusting for trial treatment group, center, gender, race, body mass index, diabetes, current treatment with chronic dialysis, and prior arteriovenous vascular access or central venous catheter were performed to compare outcomes of forearm (fAVG) and upper arm (uAVG) grafts, including loss of primary unassisted patency (LPUP) and cumulative primary graft failure (CGF). Subgroup analyses of graft configuration and outflow vein used were also conducted.**

Results: **A total of 508 of the 649 participants (78%) enrolled in the trial had an upper extremity brachial artery graft placed, 255 with fAVG and 253 with uAVG. Participants with fAVG were less often male (33% vs 43%; $P = .03$), African American (62% vs 78%; $P < .001$), and receiving dialysis at the time of surgery (62% vs 80%; $P < .001$). Participants with fAVG had a higher mean body mass index (33 vs 29; $P < .001$). The LPUP (fAVG 70% vs uAVG 78%; $P = .07$) and CGF (33% vs 36%; $P = .91$) were similar between fAVG and uAVG at 1-year follow-up. In multivariable analysis, AVG location (uAVG vs fAVG) was not associated with LPUP (hazard ratio, 1.21; 95% confidence interval, 0.90-1.63; $P = .20$) or CGF (hazard ratio, 1.36; 95% confidence interval, 0.94-1.97; $P = .10$). LPUP did not differ significantly between fAVG and uAVG among subgroups based on AVG configuration ($P = 1.00$) or outflow vein used ($P = .16$).**

Conclusions: **Patency was comparable between fAVG and uAVG despite the larger caliber veins often encountered in the upper arm in carefully selected patients. Our findings support the traditional view that, in order to preserve a maximal number of access sites, the forearm location should be considered first before resorting to an upper arm graft. (J Vasc Surg 2015;62:1258-65.)**

The most commonly used method of renal replacement therapy in the United States, hemodialysis, is performed using either an autogenous arteriovenous fistula (AVF), a prosthetic arteriovenous graft (AVG), or a central venous catheter.[1] Although a mature AVF is superior to an AVG,[2-14] there may be situations in which placement of the latter may be clinically indicated.[8,15-18] Two examples are a history of prior AVF maturation failure or lack of suitable superficial veins for AVF creation.[6-8,15] A forearm AVG (fAVG) can also be used as a temporary "bridge" to an upper arm fistula.[6,8] Potential benefits of AVG compared with AVF are availability of a variety of shapes and configurations, a short waiting period between AVG placement and cannulation, and greater technical ease of cannulation resulting from a larger access surface area.[6,8,15,19-21]

Although prosthetic AVGs are often placed in the upper extremity, they vary with respect to location, configuration, material, feeding artery, and draining vein.[1,4-7,15,22-27] The optimal graft location (upper arm or forearm) and graft configuration (straight or looped) are unknown.[5,28,29] Placement of an fAVG has the advantage of preserving upper arm veins for a future upper arm access site and may increase the suitability of upper arm veins for future upper arm AVF.[1,6] Although not definitive, some studies had observed lower patency rates for fAVG compared with upper arm AVG (uAVG).[4,6,8]

From the Division of Vascular and Endovascular Surgery, Boston University Medical Center, Boston[a]; the Division of Vascular Surgery, Louisiana State University Shreveport Health Sciences Center, Shreveport[b]; the Department of Quantitative Health Sciences, Cleveland Clinic, Cleveland[c]; the Renal, Electrolyte and Hypertension Division[d] and Center for Clinical Epidemiology and Biostatistics,[g] University of Pennsylvania Perelman School of Medicine, Philadelphia; the Section of Nephrology, University of Iowa, Iowa City[e]; the National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, Bethesda.[f]

*The DAC Study Group members can be found in the Appendix at the end of this article.

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Correspondence: Alik Farber, MD, Division of Vascular and Endovascular Surgery, Boston Medical Center, 88 E Newton St, Collamore 5, Ste D506, Boston, MA 02118 (e-mail: alik.farber@bmc.org).

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uAVGs may offer higher patency rates because they usually drain into larger caliber veins. However, use of uAVG as a first AVG choice results in passing over potential distal forearm sites.

We compared unassisted graft patency and other outcomes of newly placed fAVGs and uAVGs among participants of the Dialysis Access Consortium (DAC), a multi-center, randomized double-blind placebo controlled clinical trial of dipyridamole plus aspirin for newly placed AVGs (the DAC Graft Trial).[30,31] We also evaluated the associations between AVG patency and location, configuration, and venous outflow.

METHODS

Study population. We conducted a retrospective subgroup analysis of the DAC Graft Trial to examine the relationships of the location and configuration of newly placed upper extremity AVGs with graft patency. The study design and primary results of the trial have been previously reported.[30,31] Participants were randomized in equal proportions to either to dipyridamole plus aspirin or matching placebo. The primary outcome of the trial was unassisted graft patency. The trial, conducted at 13 clinical centers in the United States, enrolled participants from January 2003 to July 2007; follow-up stopped in January 2008. The decision for the choice of AVG location and configuration was left to the treating physician. Participants were assessed monthly after receiving an AVG and until 1 month after the graft occlusion or study end. Blood-flow rates were measured monthly by ultrasound indicator dilution after dialysis was initiated. All participants provided written informed consent, and the institutional review board of each participating clinical site approved the protocol of the trial.[30,31]

A total of 649 participants were randomized. The grafts were placed most often in the upper extremity (92.6%) and the most common material was polytetrafluoroethylene (PTFE) (94%). For our analysis, we included all participants with upper extremity PTFE AVG that utilized the brachial artery as the inflow artery. We limited our inflow to the brachial artery because of its common use for AVG construction both in this study and in clinical practice. Venous outflow in our cohort included both superficial and deep upper extremity veins such as the medial antecubital, cephalic, basilic, brachial, and axillary veins. Five hundred and eight patients with upper extremity AVG were included in the final sample for analysis. Participants excluded from analyses were those with non-PTFE grafts of biologic materials (n = 38), non-upper extremity AVGs (n = 45), and AVGs where arterial inflow other than the brachial artery was used (n = 58).

Patients were followed monthly after AVG placement to examine the access site, and to record access-related complications as well as hospitalizations.[30,31] The follow-up was continued until 1 month after the occurrence of primary outcome.[30,31]

Outcomes. Our primary outcome was the loss of primary unassisted patency (LPUP) as used in the DAC Graft Trial,[30,31] or primary patency,[32] defined as either first occurrence of graft thrombosis, an access procedure performed to correct a stenosis of 50% or more of the diameter of the adjacent normal vessel, or other surgical modifications of the graft, including those needed as a result of infection.[31] The trial protocol required participants to be referred for angiography if the blood-flow rate at the access site declined from baseline to less than 600 mL/min or if the rate declined to less than 1000 mL/min and represented more than a 25% reduction from baseline.[31]

Our secondary outcome was cumulative graft failure (CGF), as used in the DAC Graft Trial[30,31] or secondary patency,[32] defined as the time from randomization to complete loss of the access site for hemodialysis. For patients undergoing regular hemodialysis treatments using a catheter at the time of AVG placement, complete graft failure was defined as the failure to use the AVG for hemodialysis by 12 weeks after placement. Among study participants who were not yet receiving hemodialysis treatments at the time of AVG placement, the loss of graft patency was defined as the absence of both a bruit and thrill on physical examination during monthly follow-up.[31]

Access-related complications including infection and steal, and hospital admission for ischemic heart disease, congestive heart failure, and cerebrovascular disease were also evaluated.

Statistical analysis. Baseline demographic and clinical characteristics were described for participants with fAVG and uAVG and compared using the χ^2 test for categorical variables and the Student *t*-test for continuous variables. Cumulative incidence for the primary and secondary outcomes was evaluated using Kaplan-Meier estimates. Access-related complication rates and hospitalization were compared using the Fisher exact test.

Cox proportional-hazards regression models were used to examine the effects of access location on the study outcomes. The models were adjusted for treatment group (dipyridamole plus aspirin or placebo), clinical center, gender, race, body mass index (BMI), hemodialysis at the time of graft placement, time on dialysis, outflow vein, and history of previous access surgery. To assess the effect of graft configuration (straight vs looped), we fit a model with terms for configuration and its interaction with access location, and compared straight fAVG, straight uAVG, and looped uAVG, using forearm looped AVG as reference. The association was expressed as a hazard ratio (HR) with the corresponding 95% confidence interval (CI).

Subgroup analyses of graft configuration and the outflow vein were conducted separately. We evaluated the effect of AVG configuration among participants with upper extremity AVG (fAVG and uAVG) and uAVG, respectively. Additional analysis was performed to evaluate the association of different outflow veins with the AVG outcomes. Further analyses compared primary and secondary outcomes of fAVG based on any outflow vein with uAVG based on any outflow vein, uAVG based on brachial or axillary outflow veins, and uAVG based on axillary vein