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Original Article

The Effect of Artery and Vein Size on Forearm Hemodialysis Arteriovenous Graft Patency

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Objective: Arteriovenous grafts (AVGs) are considered to be an alternative procedure when autogenous fistulas are not feasible. This study was conducted to establish a correlation between the inflow artery and outflow vein size and patency of AVGs.

Materials and Methods: This was a retrospective descriptive study. Data was collected from patients who had forearm AVG performed at a university hospital from January 1, 2012, to December 31, 2016. Spearman's rho correlation test was used to identify the correlation between the artery and vein size and patency of AVG.

Results: A total of 34 patients were enrolled in this study. Forearm loop configuration was performed in 33 patients (97%), and straight configuration was performed in one patient (3%). The median size of the brachial artery was 3 mm (interquartile range [IQR]: 2, 4) and that of the vein was 3 mm (IQR: 2, 5). The overall primary patency was 74% at six months, 59% at one year, and 32% at two years. The analysis showed that the primary patency increased with the artery size, but there was a reverse correlation between vein sizes.

Conclusion: Small inflow arteries may reduce the primary patency, but small veins do not result in a poor primary patency. Our method can be applied to patients with small veins, where it is still possible to perform forearm AVGs.

Keywords: arteriovenous graft, hemodialysis

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Introduction

In order to obtain a good patency and a low complication rate, autologous arteriovenous fistulas (AVFs) are the first choice for hemodialysis access, and arteriovenous grafts (AVGs) are considered an alternative procedure when AVFs are not feasible. The patency of AVGs varies with respect to the location, configuration, material, inflow artery, and outflow vein, but the optimal diameter of the inflow artery and outflow vein is not definitely known, especially in patients where almost all the upper extremities' outflow veins are exhausted. The current recommendations are mostly based on non-Asian populations. This study was conducted to establish a correlation between the inflow artery and outflow vein size and the patency of AVGs.

Materials and Methods

After obtaining an approval from the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University, for this retrospective descriptive study, data were collected from the medical records of patients who had forearm AVG performed at King Chulalongkorn Memorial Hospital by a single surgeon (the first author) from January 1, 2012, to December 31, 2016.

All patients undergoing vascular access procedures would receive an upper-extremity Doppler ultrasound to study the vessels, documenting the target vessels and deciding the best access procedure for the patient: either a native AVF or graft interposition. Systolic blood pressure in both arms was measured, and the modified Allen's test performed. If the results were unsatisfactory or the patient had moderate to severe atherosclerosis, we did not proceed with the procedure. The intraoperative findings were the final decisive factor on whether to proceed with the procedure or stop and choose another route for access.

The AVG fistula was performed using a standard wall polytetrafluoroethylene tube (diameter: 6 mm) with end-to-side anastomoses using polypropylene 6/0 sutures. The primary outcome was a correlation between the size of the inflow artery and outflow vein and the primary patency.

Table 1 Factors affecting the primary patency among 34 patients undergoing AVG

	n	Primary patency (days)	
		Median (IQR)	P-value
Sex			
Male	9	380 (313, 747)	0.682
Female	25	477 (86, 750)	
Diabetes			
No	15	477 (200, 800)	0.665
Yes	19	380 (149, 747)	
Hypertension			
No	6	469.5 (373, 800)	0.527
Yes	28	428.5 (117.5, 748.5)	
Underlying heart disease			
No	22	491 (313, 760)	0.368
Yes	12	331 (59, 748.5)	
Documented lower-extremity arterial occlusive disease			
No	31	477 (149, 760)	0.879
Yes	3	374 (187, 750)	
Medication			
Aspirin			
No	17	608 (313, 800)	0.235
Yes	17	374 (149, 530)	
Clopidogrel			
No	28	491 (297.5, 755)	0.136
Yes	6	117.5 (32, 526)	
Anticoagulant			
No	33	409 (187, 750)	0.445
Yes	1		
Smoking			
No	15	380 (149, 694)	0.522
Yes	1		
N/A	18	569 (347, 800)	
Indication			
Preemptive	6	716.5 (409, 760)	0.206
On hemodialysis	28	377 (117.5, 748.5)	
Side			
N/A	5	477 (347, 739)	0.023*
Right	11	200 (22, 380)	
Left	18	638.5 (373, 877)	
Configuration			
Loop	33	409 (187, 747)	0.285
Straight	1		
Venous outflow site			
N/A	1		0.717
Brachial-cephalic	11	409 (17, 750)	
Brachial-basilic	14	428.5 (313, 739)	
Brachial-antecubital	8	447 (136.5, 797.5)	

Values are presented as mean±standard deviation (SD) and median (IQR). The P-values correspond to the Mann–Whitney U test.

The secondary outcome was a primary patency rate and secondary patency rate of AVG.

Demographic data were reported as a mean with a standard deviation or median (interquartile range [IQR]). Clinical factors were analyzed using the Mann–Whitney U test. Spearman's rho correlation test was used to define the correlation between the size of the vessel and the primary patency. A P-value of <0.05 was considered significant.

Results

Patients' and procedure characteristics

Forearm AVG was performed in 34 patients (25 females [74%], nine males [26%], mean age: 64.9±17.8 years). Nineteen patients (56%) had diabetes mellitus, 28 (82%) had hypertension, 12 (35%) had coronary heart disease, and three (9%) had a documented lower-extremity arterial occlusive disease. Twenty-eight patients (82%) underwent hemodialysis before forearm AVG placement, and six patients (18%) were preinitiation for dialysis. Seventeen patients (50%) were on aspirins, six patients (18%) were on clopidogrel, and one patient (3%) was on an anticoagulant (**Table 1**). Forearm loop configuration was performed in 33 patients (97%), and straight configuration was performed in one patient (3%).

The brachial artery was chosen as the inflow artery in all cases. According to the results of preoperative evaluation and the surgeon's preference, the outflow vein was chosen as follows: 41% basilic vein, 32% cephalic vein, and 24% antecubital vein. The median size of the brachial artery was 3 mm (IQR: 2, 4) and that of the vein was 3 mm (IQR: 2, 5) (**Table 2**).

Patency and correlation with the size of the chosen vessels

The overall primary patency rate was 73.5% at six months, 58.8% at one year, and 32.4% at two years. The median of the primary patency was 443 days (IQR: 9, 1,399). The AVG performed on the left forearm had

Table 2 Procedure characteristics

Characteristics	N (%) or mean±SD	Median [min, max]
Configuration		
Loop	33 (97%)	
Straight	1 (3%)	
Venous outflow site		
Basilic vein	14 (41%)	
Cephalic vein	11 (32%)	
Antecubital vein	8 (24%)	
N/A	1 (2.9%)	
Artery inflow (mm)	3.18±0.52	3 [2, 4]
Vein outflow (mm)	3.01±0.71	3 [2, 5]

a significantly higher primary patency than that on the right forearm (P = 0.023), but other characteristics did not have an influence on patency (**Table 1**). The AVG primary patency increased with the artery size (Spearman's rho: 0.219, P = 0.213), but there was a reverse correlation between the vein size and the primary patency with no statistical significance (Spearman's rho: −0.208, P = 0.237). Thrombosed AVG was salvaged in 11 patients (32.3%). The median of the secondary patency was 905 days (IQR: 62, 1,535), and a good secondary patency after AVG salvaging was correlated with a previous good primary patency (Spearmen's rho: 0.982, P = 0.001) (**Table 3**, **Figs. 1** and **2**).

Discussion

AVF is the first treatment choice in hemodialytic patients because of its high functional patency and low complication rate.[1,2] However, AVGs are an alternative procedure in some situations such as patients with poor superficial veins and morbid obesity and patients who require early cannulation with avoidance of a central venous catheter and a graft can be used as "planned bridge" to a more proximal fistula creation in the future.[1,3,4] In our study population, female patients had more AVGs than males, which may be due to the poor quality of the veins for an AVF in females. When an AVG is performed, priority is set as in the following sequence: forearm loop→straight or curved upper-arm loop→upper-arm loop.[1] Many authors reported that the primary patency for AVG is 58% at six months, 33.9–90% at one year, and 25.3–85% at two years[3,5,6] and that the secondary patency was 76% at six months, 64% at one year, and 57.7% at two years.[1,6] Many factors that may affect the patency of AVG have been proposed, such as medication (clopidogrel, aspirin, and dipyridamole), coronary disease, serum cholesterol level, location, and configuration.[7,8] In our study, no improvement of patency was shown among patients on antiplatelet or anticoagulant therapy (**Table 1**). In many studies, the correlation between the location of AVG and the patency has been evaluated, and these results may imply that the more proximal the anastomosis the larger the vessel and better patency.

We considered arterial inflow as an important component in configuring vascular access and noticed that if the size of an atherosclerosis-free artery is greater than 3 mm, it will have a good patency rate. One patient in our study population had good-quality cephalic veins at the wrist, but small radial arteries, so the chosen procedure was a straight interposition graft from the brachial artery to the cephalic vein at the wrist with a good patency (**Table 2**). If patients with a primary patency less than 30 days were to be excluded in order to eliminate the effect of the surgical technique, five patients would be excluded. The analysis still showed a positive correlation between the artery size and the primary patency (Spearman's rho: 0.202, P = 0.29) and a negative correlation between the vein size and the primary patency (Spearman's rho: −0.166, P = 0.39), with no statistical significance.

When considering outflow for graft interposition, the

Table 3 Correlation among the artery inflow, vein outflow, primary patency, and secondary patency

Variables	Primary patency (days)		
	N	Spearman's rho (r)	P-value
Artery inflow size	34	0.219	0.489
Vein outflow size	34	−0.208	0.237
Secondary patency (days)	11	0.982	0.001*

Values are presented as a correlation (r). The P-values correspond to Spearman's rho correlation test.

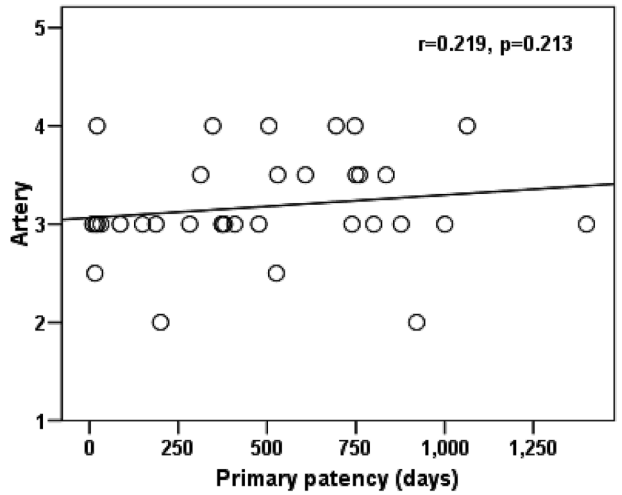

Fig. 1 Correlation between the artery inflow and primary patency.

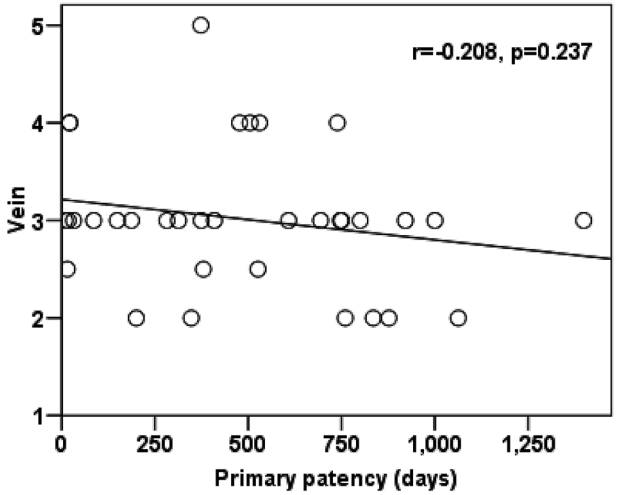

Fig. 2 Correlation between the venous outflow and primary patency.

vein size is important for anastomosis, but the patency and flow rate depend on the outflow. In our practice, the target vein was chosen with a size not less than 2 mm, in which the tributaries were preserved at all costs in order to have good outflow even with a small vein size.

Mousa et al. examined the patency in AVG, in which the locations of the grafts were 80% arm, 15% forearm, and 5% thigh. They found that the primary patency was not different with respect to the location and configuration of the graft.[7] Farber et al. evaluated the relationships between the location and configuration of AVG and patency in 508 patients (255 with forearm AVG and 253 with upper-arm AVG). Patency was comparable between forearm AVG and upper-arm AVG, although the larger caliber veins were often encountered in the upper-arm.[9] Our study showed no statistically significant difference in the primary patency between outflow vein sizes smaller than and larger than 3 mm (526 days [IQR: 347, 835] versus 409 days [IQR: 149, 739], P = 0.380), and the correlation between outflow vein sizes was negative. This correlation means that when the outflow vein size is increased, the primary patency is reduced, but with no statistical significance as well (P = 0.237).

In a multicenter retrospective study, Suemitsu et al. compared the patency of forearm AVGs on the basis of the radial artery and brachial artery inflow in 150 patients. The primary patency rate was significantly different between the radial artery and brachial artery inflow at one year (53.8% versus 24.4%, P = 0.032).[10] Our study showed a different result: in all cases, the inflow artery chosen in our study was the brachial artery with a size larger than 2 mm. Moreover, the primary patency was 58.82% at one year. An artery with a larger size tended to provide a better primary patency, but with no statistical significance (P = 0.213). Additional analyses demonstrated that a good secondary patency after AVG salvaging was observed in patients who had a good primary patency before the AVG was thrombosed.

The limitations of this study were its retrospective design, the small number of patients, and the selection bias in the surgical technique. Hence, further studies are needed.

Conclusion

Small inflow arteries may reduce the primary patency, but small veins do not always result in a poor primary patency. Our method can be applied to patients with exhausted upper-extremity outflow veins. Even though the Asian population have a smaller body habitus, following the guidelines for the recommended vessel size may not be suitable. Forearm AVG can be used before upper-arm AVG is chosen in order to preserve more proximal sites for new access in the future.

Disclosure Statement

The authors have no conflict of interest to disclose.

Author Contributions

Study conception: all authors
Data collection: PA
Analysis: PA
Investigation: all authors
Writing: KK, PA
Funding acquisition: none
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

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