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Forearm Loop Arteriovenous Grafts Preserve and May Create New Upper Arm Access Sites

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Abstract

Introduction: This study evaluated the mid-term patency of forearm loop arteriovenous grafts (flAVG) and the dilation of previously inadequate upper arm basilic and cephalic veins after failed flAVG.

Methods: All access procedures from 9/2009–12/2015 were reviewed. Vein mapping measurements were used to determine if there was "adequate" upper arm cephalic and/or basilic vein, defined as ≥3 mm by duplex ultrasound, at the time of flAVG creation. Outcomes of flAVG were compared with upper arm AVF, and primary and cumulative patency were evaluated.

Results: Thirty-eight flAVG and 278 upper arm AVF were created. In the flAVG cohort 9 were inserted with adequate upper arm vein, group A, and 29 were inserted with inadequate upper arm vein, group B. Cumulative patency was lower for flAVG compared with upper arm AVF at six months, one year and two years (67% vs. 91%, 61% vs. 85%, and 49% vs. 80%, respectively P<.01). Comparison of group A flAVG and upper arm AVF did not show a statistical difference in cumulative patency at six months, one year, and two years (P=.80, .62, and .70, respectively). Of group B with failed flAVG, 36% became candidates for upper arm AVF with dilitation of ipsilateral upper arm cephalic or basilic vein to ≥3 mm.

Conclusions: In this study, flAVG with adequate upper arm vein did not show a statistical difference in mid-term patencies compared with upper arm AVF. For those flAVG with inadequate upper arm vein, approximately one-third of patients became candidates for upper arm AVF demonstrating the benefits flAVG.

Keywords

Forearm Loop Graft; Vascular Access; Hemodialysis

Introduction

As the average life expectancy of patients with end-stage renal disease (ESRD) has increased in contemporary practice, patients on hemodialysis (HD) are likely to require more than one access creation.[1–2] Therefore, preservation of potential HD access sites is an emphasis of current guidelines as patients may experience multiple access failures during

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their lifetime.[3–5] To preserve access sites, a wrist or forearm arterio-venous fistula (AVF) is recommended to be the first site of HD access. However, patients may not be candidates for distal AVF creation due to inadequate cephalic vein, diseased radial artery, or prior failure.[6–8]

When patients are not candidates for wrist AVF, current guidelines recommend upper arm AVF if there is suitable vein; however this decision of next access is controversial.[9–12] Currently, arteriovenous grafts (AVG) are not recommended unless no suitable vein is available. Studies are limited regarding the outcomes of forearm loop AVG (flAVG) with respect to their influence on upper arm superficial veins. The advantages of creating a flAVG rather than proceeding directly to an upper arm brachio-cephalic or brachio-basilic AVF creation include: early access for HD, preservation of upper arm HD access sites, and possible dilation of diminutive upper arm cephalic and basilic veins from increased arterial flow thereby increasing potential access sites.

The objective of the study is to evaluate the perceived advantage of creating flAVG prior to placement of an upper arm access. We performed a retrospective analysis of flAVG placed in patients without a forearm fistula option and studied the mid-tern patencies and subsequent access procedures in comparison to those who received an upper arm fistula.

Methods

This retrospective observational study evaluated patients who underwent flAVG and upper arm AVF creation for HD from September 2009 through December 2015. This study was approved by the institution's IRB and patient consent was waived given the retrospective nature of the study.

Patients were identified during the study period by CPT codes (36818 [Upper arm cephalic transposition], 36819 [Upper arm basilic transposition], 36821 [AVF creation, any site] and 36830 [AV graft]). Individual patient charts were investigated to determine the type of configuration for upper arm graft: forearm loop versus brachial-axillary AVG. Upper arm AVG as well as forearm and wrist AVF were excluded from the analysis.

Using electronic medical records from our hospital connected to surrounding institutions, collected data included patient demographics, comorbidities, previous HD access information, pre-operative vein mapping measurements, and follow-up regarding patency and secondary procedures. Pre-operative vein mapping measurements were used to determine the adequacy of upper arm cephalic and/or basilic vein at the time of upper arm AVF or flAVG creation, defined as vein diameter vein ≥ 3 mm by duplex vein mapping. For flAVG the larger of the two upper arm vein measurements was reported and used for statistical comparison. Additionally, the adequacy of upper arm vein after a flAVG failure, also defined as ipsilateral cephalic or basilic upper arm vein ≥ 3 mm by duplex vein mapping, was investigated.

Primary and cumulative patency for upper arm AVF (brachio-cephalic and brachio-basilic) and flAVGs was evaluated using Kaplan-Meier survival analysis. Primary patency was defined as time from HD access creation to time of a secondary procedure or failure of access site. Second stage basilic vein superficialization was not considered a secondary procedure. Cumulative patency was defined as time of access creation to permanent failure. The primary and cumulative patency was compared at 6 months, 1-year and 2-years using the Mantel-Cox log-rank test. Descriptive statistics were used to evaluate study demographics, comorbidities, and outcomes variables as appropriate between cohorts. Categorical variables were compared with chi-squared or Fisher exact tests and continuous variables were compared with a t-test or Mann-Whitney U test. A P-value of <0.05 was consider statistically significant. Statistical analysis was performed by SAS Studio 3.6 (Cary, NC).

Results

A total of 278 upper arm AVF (157 brachio-cephalic AVF and 121 brachio-basilic AVF) and 38 flAVG were created during the study period. In the flAVG cohort, nine were inserted with adequate ipsilateral upper arm vein (group A), and 29 were inserted without adequate upper arm vein (group B). Patients receiving a flAVG were older compared with those receiving upper arm AVF (65.2 ±13.8 vs. 57.7 ±16.6 years, P<.01). Patients with flAVG also were more likely to have hypertension and hyperlipidemia (Table 1). Current dialysis at the time of HD access creation was more common for the flAVG group compared to the upper arm AVG group (95% vs. 77%, P<0.01); however, previous ipsilateral forearm and upper extremity access procedures were not statistically different between the two groups (Table 1).

Pre-operative ultrasound vein measurements of the upper arm cephalic and basilic veins were smaller for flAVG (2.4±0.9 mm) compared to upper arm AVF (3.4±0.9 mm), P<.01 (Table 1). When stratifying by flAVG group, group A flAVG (3.3 ± 0.3 mm) and upper arm AVF were not statistically different, P=.50. Group B flAVG (2.2 ± 0.9 mm) had smaller pre-operative veins compared with the upper arm AVF group, P<.01.

The median follow-up was 25.7 months (Interquartile range (IQR) 10.9– 41.7 months). A total of 40 patient deaths were identified during follow-up (14.4% for upper arm AVF vs. 7.9% for flAVG, P=.34) at a median of 23.5 months (IQR 10.4–33.7) after HD access creation.

The primary patency of brachio-cephalic and brachio-basilic AVF at 6-months, 1-year, and 2-years were not statistically different between the two groups (68% vs 66%, 57% vs. 52%, and 46% vs. 33%, P=.64, .80, and .59 respectively). The cumulative patency brachio-cephalic and brachio-basilic AVF at 6-months, 1-year, and 2-years were also not statistically different (91% vs. 91%, 88% vs. 80%, 86% vs. 71%; P=.32, .64, and .82, respectively).

The primary patency rates at 6-months, 1-year, and 2-years were significantly lower for combined flAVG compared with upper arm AVF (52% vs. 67%, 39% vs 55%, 25% vs. 41%, P<.01; Figure 1a). The cumulative patency rates were also significantly lower for flAVG compared with the upper arm AVF group (67% vs. 91%, 61% vs. 85%, and 49% vs. 80%, P<.001; Figure 2a).

When stratifying flAVG by suitability of the upper arm superficial veins at the time of access placement, group A flAVG primary and cumulative patency were not statistically signficaint compared to upper arm AVF (Figure 1b, 2b). Conversely, group B flAVG demonstrated inferior primary and cumulative patency compared to the upper arm AVF group (Figure 1b, 2b).

During follow-up 16 flAVG failed at a median of 5.5 (IQR 2.5–10.9) months. Two failures occurred in patients in group A flAVG at 4.3 and 22 months; and both went on to upper arm AVF placement. The 14 remaining failures in group B flAVG occurred at a median of 5 (2.9–13.2 IQR) months.. Of these, three went directly to upper arm AVG without repeat vein mapping. For the remaining eleven patients with repeat vein mapping, five patients had developed dilation of the upper arm ipsilateral cephalic and/or basilic vein to ≥3 mm after flAVG failure and went on to upper arm AVF creation (Figure 3). The average increase in upper arm vein diameter after failed flAVG was 0.7 ± 1.3 mm.

Percentage of access sites requiring secondary procedures in the group A flAVG was higher than the upper arm AVF group but this did not reach statistical significance (78% vs. 49%, P=.17; Table 2). The average number of secondary procedures in group A flAVG was higher than the upper arm AVF group but this did not reach statistical significance (2.4±1.3 vs. 1.9 ±1.2, P=.10). The median time to the first secondary procedure was shorter for upper arm AVF compared with group A flAVG (9.6 vs. 5.7 months, P <.01), but was no different for group B flAVG (3.7 months, P=.21). Steal occurred in two patients in each of the flAVG and AVF groups. Infection requiring surgical revision and graft resection developed in two patients after flAVG creation and one patient after AVF creation.

Discussion

As patients with ESRD are likely to require multiple dialysis accesses, this study supports the utility of incorporating flAVG in long-term strategies for HD access. In the study population when flAVG were inserted with ≥ 3mm ipsilateral superficial upper arm vein (group A), mid-term patencies were not statistically significant when compared with upper arm AVF. When flAVG failed in this group, upper arm AVF was successful in all patients. As flAVG does not routinely sacrifice future upper arm AVF access creation, this study provides evidence to consider creating a flAVG before directly proceeding to an upper arm AVF creation. For those who were not initial candidates for upper arm AVF creation, approximately one-third of these failed flAVG patients developed adequate upper arm cephalic and/or basilic veins and had successful upper arm AVF creation. For these patients, the flAVG served as a bridge to an upper arm AVF and they would not have been candidates for upper arm AVF had an upper arm graft been placed instead.

Under current guidelines, upper arm AVF are recommended over the placement of an AVG when adequate vein is available, as cumulative AVG have lower patencies, require more intervention, and have higher infection rates.[13] However, these guidelines are based on studies that include wrist and forearm AVF in the analyses.[14–18] Although the Fistula First Initiative increased the use of AVF for HD dramatically in the United States from 24% in 1997 to 68% in 2013,[19] recent evidence has supported the use of AVG placement in certain situations highlighting the complexity of patient factors and variation in decision making.[20–23]

The advantages of AVG creation include quicker time to cannulation, fewer interventions prior to cannulation, lower primary failures, and shorter catheter dependence. Additionally, converting failed AVG to a secondary AVF in the upper arm reduced catheter days and the patency is similar to AVFs created in other locations.[24] Another advantage of flAVG is accessing a flAVG may be technically less difficult than accessing an upper arm AVF in obese patients. In the elderly population these advantages have led to further support of AVG insertion.[25–28]

The number of potentially available HD access sites is an often overlooked variable, and may be important in long-term planning of patients with ESRD. Although primary failures are documented in follow-up, the total number of access sites a patient experiences in a lifetime is not well reported. A study of Medicare beneficiaries from the 1990's showed 8.2% of patients underwent more than two HD access creations in a year, highlighting that preservation of HD access sites is important.[29] In this study, one-third of patients had dilation of upper arm veins creating a new autologous AVF creation site after a failed flAVG and none sacrificed a future upper arm AVG creation.

This study is subject to limitations owing to the retrospective nature and relatively small number of patients who underwent a flAVG creation during the study period. Although this study did not find a statisticaly significant difference of primary and cumulative patency between upper arm AVF and flAVG creation with ipsilateral upper arm vein ≥3mm, type 2 error may exist given the limited number of patients and further studies are warranted to validate these observations in a larger population. Also given the limited patient size the effects of graft material, outflow vein anastomosis location, and post-operative medications on the patency rates were not analyzed.

This study was not able to fully analyze the time of catheter days in the study as our institution does not serve as a dialysis center, and this data is incomplete regarding functional patency. However, it is likely that catheter days were shorter in the flAVG as 95% of patients were currently on dialysis in the flAVG groups compared to 77% for the upper arm AVF group. A comparison of flAVG and brachio-axillary AVG outcomes is not included in this analysis as this is beyond the scope of the study and addresses a separate clinical question when no AVF access sites are favorable.

Conclusion

This study demonstrated flAVG have comparable mid-term primary and cumulative patencies compared with upper arm AVF when flAVG are placed with ≥3 mm ipsilateral upper arm vein at time of insertion, but note the possibility of type 2 error given the limited patient sample. In circumstances when upper arm vein is <3 mm, flAVG insertion provides an additional benefit of increasing HD access sites via dilation of upper arm veins in approximately one-third of patients, a finding which needs confirmation in larger studies.

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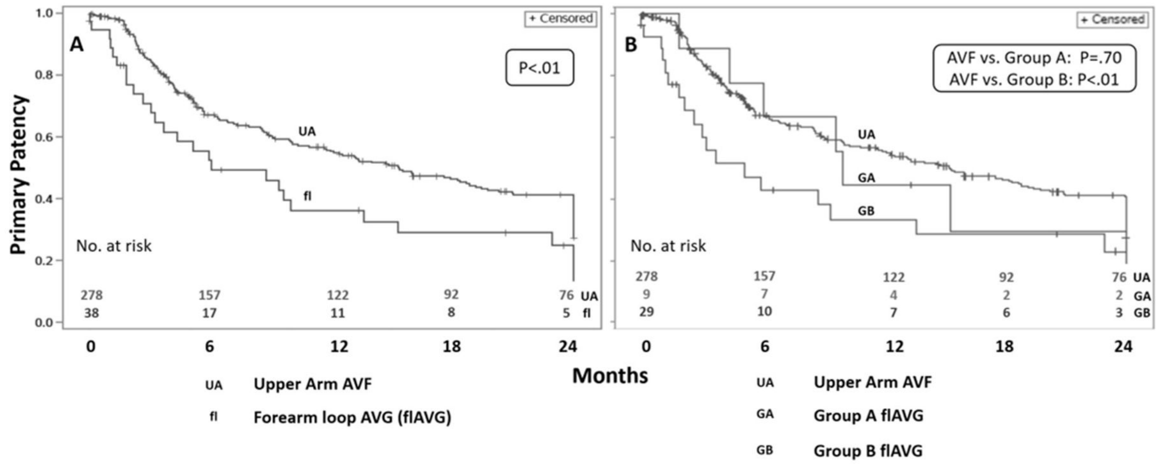

Figure 1.

Primary-patency upper arm AVF and flAVG. A. Upper arm AVF versus combined flAVG. B. Upper arm AVF versus flAVG with upper arm vein diameter stratification.

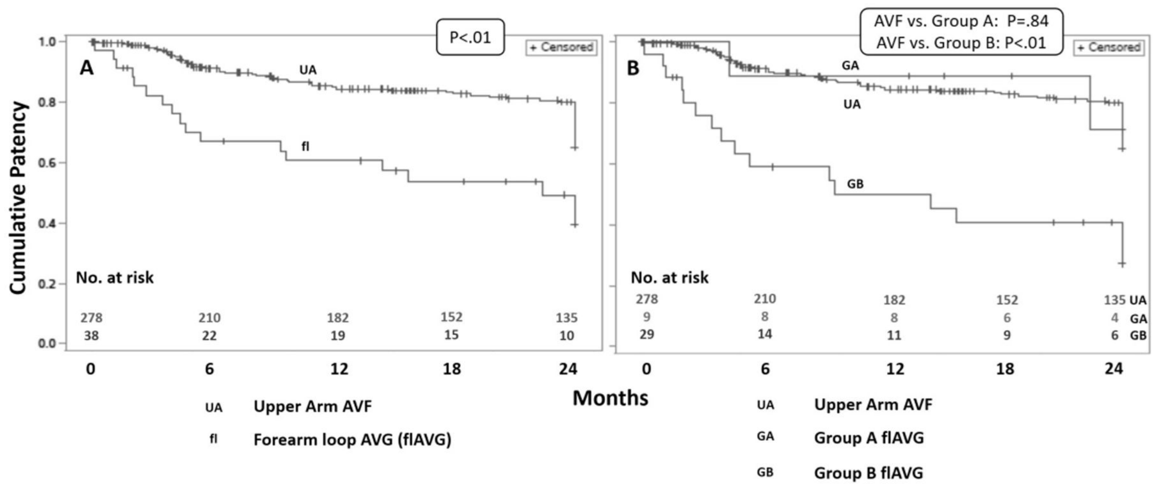

Figure 2.

Cumulative-patency upper arm AVF and flAVG. A. Upper arm AVF versus combined flAVG. B. Upper arm AVF versus flAVG with upper arm vein diameter stratification.

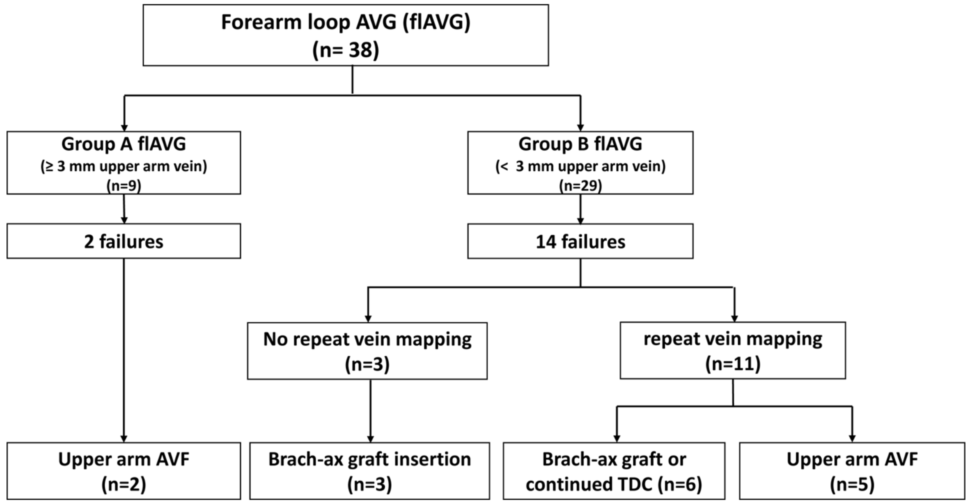

Figure 3.
Outcomes regarding secondary creation of dialysis access after failed flAVG.

Table 1.

Patient demographics and pre-operative characteristics

	Upper Arm AVF (n = 278)	Total fAVG (n=38)	P-value
Age	57.7±16.6	65.2±13.8	<.01
Male Sex (%)	175 (63)	25 (66)	.87
BMI	28.2±6.7	29.4±6.9	.30
Hypertension (%)	230 (82)	37 (97)	.04
Hyperlipidemia (%)	118 (42)	29 (76)	<.01
CAD(%)	48 (17)	11 (29)	.13
CVA (%)	42 (15)	11 (29)	.06
COPD (%)	28 (10)	2 (5)	.51
DVT (%)	51 (18)	5 (13)	.58
Tobacco – current (%)	23 (8)	3 (8)	.94
Aspirin (%)	117 (42)	20 (53)	.29
Statin (%)	114 (41)	23 (61)	.04
Clopidogrel (%)	29 (10)	5 (13)	.82
Anti-coagulation (%)	25 (9)	2 (5)	.60
ACE-inhibitor (%)	76 (27)	5 (13)	.09
Current dialysis (%)	214 (77)	36 (95)	<.01
Prior Ipsilateral UE Access (%)	30 (11)	4 (11)	1.00
Prior ipsilateral Forearm Access (%)	49 (18)	6 (16)	1.00
Pre-operative vein mapping (mm)	3.4±0.9	2.4±0.9	<.01

Mean ± SD, unless otherwise noted.

CAD – Coronary Artery Disease, CVA – Cerebral Vascular Accident, COPD – Chronic Pulmonary Obstructive Disease, DVT – Deep Vein Thrombosis

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Table 2 .

Secondary procedures of upper arm AVFs versus flAVGs with upper arm vein diameter stratification

	Upper Arm AVF (n = 278)	Group A flAVG (n=9)	P-value	Group B fAVG (n=29)	P-value
Percentage requiring secondary procedures	48%	78%	.17	44%	.77
Average number of secondary procedures ± SD	1.9 ± 1.1	2.4 ± 1.3	.10	1.9 ± 1.2	.97
Median time to first secondary procedure – months (IQR)	5.7 (3.0–15.5)	9.6 (5.2 – 12.6)	<.01	3.7 (2.2–9.4)	.21