Vascular Specialist International
Vol. 32, No. 4, December 2016
pISSN 2288-7970 • eISSN 2288-7989

Original Article

Long Term Outcomes of Arteriovenous Grafts for Hemodialysis in Lower Extremities

Seok Han, Dan Song, and Sangchul Yun

Department of Surgery, Soonchunhyang University College of Medicine, Cheonan, Korea

Purpose: The lower extremity has received its fair share of attention as a vascular access site in patients who have exhausted their upper arm vessels. However, experiences with lower extremity arteriovenous grafts (AVGs) have so far been disappointing because of high infection rates and severe limb ischemia. We report our experience with hemodialysis access from the lower extremity.

Materials and Methods: A retrospective review of 60 lower extremity AVGs created between January 2003 and December 2011 was performed. Age, sex, etiology of end-stage renal disease and complications were tabulated. Primary and secondary patency rates were determined.

Results: The average age of the study population was 56 years and 38 patients were female. Renal failure was associated with hypertension in 40 (66.7%) patients, diabetes in 28 (46.7%) patients and cardiovascular disease in 9 (15.0%) patients. The follow-up period was 8-108 months. Fifty-four patients had bilateral central vein stenosis. Seven (11.7%) patients had primary failure of their AVG. There was no operation-related death. Primary and secondary patency rates were: 66% and 90% at 1 year, 40% and 90% at 2 years, 27% and 87% at 3 years, and 18% and 87% at 5 years, respectively. There were 105 postoperative complications that developed in 67 patients. Postoperative complications were: thrombosis (30), proximal vein stenosis (56), infection (9), bleeding with hematoma (1), perigraft seroma (3), steal syndrome (2), and pseudoaneurysm (4).

Conclusion: A lower extremity AVG seems to be a viable option in patients with unusable upper extremity veins.

Key Words: Vascular access, Arterivenous fistula, Renal dialysis, Lower extremity

Received August 29, 2016
Revised October 9, 2016
Accepted October 18, 2016

Corresponding author: Dan Song
Department of Surgery, Soonchunhyang University Seoul Hospital, 59 Daesagwan-ro, Yongsan-gu, Seoul 04401, Korea
Tel: 82-2-709-9490
Fax: 82-2-749-0449
E-mail: backsa7@schmc.ac.kr
Conflict of interest: None.

Vasc Spec Int 2016;32(4):180-185 • https://doi.org/10.5758/vsi.2016.32.4.180

INTRODUCTION

In 1966, Brescia et al. [1] first presented a surgery called autologous arteriovenous fistula (AVF). They found out that the best option for creating a vascular access for hemodialysis was a cephalic vein to radial artery fistula which is generally called an AVF. Making a prosthetic arteriovenous graft (AVG), either in the upper or lower extremity, is an alternate solution for vascular access in patients whose autologous AVFs have failed. Many authors have negative views on prosthetic AVG due to complications such as infections and limb ischemia, which can lead to amputation or more serious disease [2-5]. As a result, there was very little interest in prosthetic AVG for many decades. But recent data on prosthetic AVG have shown results different from the negative effects that many expected. There have also been a fair number of repeated problems with thrombotic occlusion, infections, steal

syndrome and central venous outflow occlusion affecting both upper extremities resulting in these upper extremity hemodialysis access sites unusable and primarily affected patients having the earlier version of prosthetic grafts. Interest in using the lower extremity as a site to create vascular access for hemodialysis has been on the rise due to improvements in modern surgical techniques and prosthetic materials. Many investigators have reported patency rates and complications of AVG through retrospective studies and review of literatures.

MATERIALS AND METHODS

From January 2003 to December 2011, 60 polytetrafluoroethylene (PTFE) grafts were operatively placed in the lower extremity of 57 patients with all the operations being performed in a single tertiary medical center. The study was approved by the Soonchunhyang University Hospital Institutional Review Board (IRB no. schuh 2016-08-12). The data included patient's demographic characteristics, comorbidities, lower extremity AVG enforcement reasons, complications and patencies. All patients had preoperative bilateral upper extremity venogram to check for central venous stenosis and evaluation of the veins. Patients with either central vein occlusion in both upper extremities or with one sided central vein occlusion of their upper extremity accompanied by contralateral upper limb amputation, infection or steal syndrome with unusable veins underwent venogram to detect for presence of stenosis. Patients with any kind of pain or claudication that had an ankle-brachial index (ABI) under 0.9 had arteriogram of the iliac and femoral arteries to check for stenosis. Patients with no stenosis in their iliac vein or no arterial problems were selected for the study. Primary patency was determined and was defined as the interval between the time of AVG placement until any necessary intervention to maintain normal AVG function or to reestablish patency. Secondary patency was also determined and was defined as the time of patency measurement, including any intervening surgical or endovascular actions designed to reestablish graft functionality. Statistical analysis to determine patency rates was performed by Kaplan-Meier method using the SPSS ver. 15.0 software (SPSS Inc., Chicago, IL, USA).

1) Operation procedure

The patients had either spinal or general anesthesia, and were placed in the supine position. The entire chosen lower extremity was prepared from the lower abdomen down to the foot. The lower extremity AVGs were placed in either a loop or straight configuration. For the loop type graft creation, about a 6-8 cm longitudinal skin incision was made below the inguinal ligament. The subcutaneous tissues in the inguinal area were dissected to expose the common femoral artery, the common femoral vein and its branches, and the great saphenous vein. A Kelly-Weck tunneler was passed to create a tunnel after which a graft was tied to its head and gently pulled through the tunnel. The distal end of the loop rested approximately 8-10 cm superior to the knee (loop type). The graft was then turned superiorly in the subcutaneous plane until it reached the exposed femoral vein. The dome on the loop was made with a smooth curvature to avoid creating an acute angle which could result in a kink. One graft end was anastomosed to the side of the common femoral artery. A longitudinal venotomy (15 mm) was made and connected to the opposite graft end which was cut obliquely, completing the graft to venous anastomosis (GVA). The total length of graft used was approximately 35-40 cm. A thrill on the graft was then checked upon removal of both the venous and arterial clamps. The skin was closed layer by layer after control of bleeding was achieved. For the straight type graft creation, the popliteal artery was exposed approximately 6-8 cm superior to the knee joint. The femoral vein at the inguinal area was used (Fig. 1A, B). All AVGs were made with non-reinforced PTFE grafts but came from different manufacturers. The most commonly used prosthetic material was the Impra (Bard PV Inc., Tempe, AZ, USA) 6 mm or 4-7 mm (tapered) graft. The diameter of the grafts ranged from 4-7 mm tapered to 6 mm straight, depending on the surgeon's choice.

RESULTS

From January 2003 to December 2011, 60 lower extremity PTFE grafts were placed in 57 patients (both thighs in three patients). The mean follow-up period was 50 months (ranging between 2-108 months) with no missed follow-ups. There were no early postoperative (30 day) deaths in this series. However, 35 patients died from systemic complications from their renal disease during the follow-up period. All patients that died during the study period had a functioning lower extremity graft at the time of death. The average patient age was 58.9 years (ranging between 34-85 years) with 22 male patients. Hypertension was present in 40 patients and was the most commonly reported comorbidity (66.7%), whereas diabetes mellitus was present in 28 patients (46.7%) and cardiovascular disease was present in 9 patients (15.0%). Fifty-seven patients had history of multiple access failures at other sites before the lower extremity hemodialysis access was created. Only 3

https://doi.org/10.5758/vsi.2016.32.4.180

patients had a lower extremity graft created as their first hemodialysis access. The reasons for performing the lower extremity graft as a primary access in these three patients were because of bilateral arm central vein occlusion (2 patients) and bilateral below elbow amputation (1 patient). Primary graft failure occurred in 7 patients: postoperative infection (3 patients), steal syndrome (2 patients), and early thrombosis (2 patients) (Table 1).

1) Complications

The most commonly reported complication of AVG was stenosis of the GVA site, with percutaneous transluminal angioplasty being required in 56 cases (28 patients). The second most reported complication of AVG was thrombosis wherein 30 cases of this complication occurred (22 patients). Twenty-one thrombosis cases received radiologically-guided intervention and 9 underwent surgical intervention (thrombectomy with bypass). Clinically significant infection occurred in 9 patients (15%). Infections that were adequately treated by antibiotics and surgical drainage were excluded from this analysis. Subtotal graft excision was required in seven of the nine clinically significant infection cases. Two patients required revision of their vascular access by means of partial excision of the infected section and interposition bypass grafting. Two patients (3%) in our study had steal syndrome. One patient with steal syndrome was managed by interposition grafting to the proximal artery and the other patient required ligation of the graft. Three patients had perigraft seroma. Two patients required removal of the perigraft seroma with interposition graft through a new tunnel while one patient was just observed and managed conservatively. Two patients (4 complications) had pseudoaneurysm. All cases required removal of the pseudoaneurysm and interposition bypass grafting. One patient had bleeding due to anastomosis site rupture. This complication required emergency operation with graft ligation and removal (Table 2).

Table 1. Patient baseline characteristics (n=60)

Characteristic	Value
Age (y)	58.9 (34-85)
Female	38 (63.3)
Hypertension	40 (66.7)
Diabetes	28 (46.7)
Cardiovascular disease	9 (15.0)
First access	3 (5.0)
Primary failure	7 (11.7)
Cause of femoral access	
Both central vein occlusion	54 (90.0)
One side central vein occlusion with contralateral arm complication (infection, arm deformity, steal syndrome etc.)	6 (10.0)

Values are presented as median (range) or number (%).

2) Patency rates

The primary patency rate was 66%, 40%, 27%, and 18% at 12, 24, 36, and 60 months, respectively (Fig. 1). The secondary patency rate was 90%, 87%, 87%, and 65% at 12, 36, 60, and 84 months, respectively (Fig. 2).

DISCUSSION

The demand for vascular access surgery is increasing rapidly because of the continuing expansion of the population needing dialysis, increasing at a rate of over 8% per year throughout the world. A reliable, functioning vascular access is a lifeline for patients with chronic renal

Table 2. Complications of lower extremity grafts for hemodialysis

Complications	Patients no.	Complications no.	Management
Proximal vein stenosis	28	56	PTA
Access thrombosis	22	30	PTA: 21 Surgical intervention: 9
Infection	9	9	SGE: 7 PGE and interposition: 2
Steal syndrome	2	2	Graft removal: 1 Bypass surgery: 1
Bleeding due to anastomosis site rupture	1	1	Removal of graft
Perigraft seroma	3	3	Observation: 1 Removal seroma, interposition: 2
Pseudoaneurysm	2	4	Removal, interposition
Total	67	105	

PTA, percutaneous transluminal angioplasty; SGE, subtotal graft excision; PGE, partial graft excision.

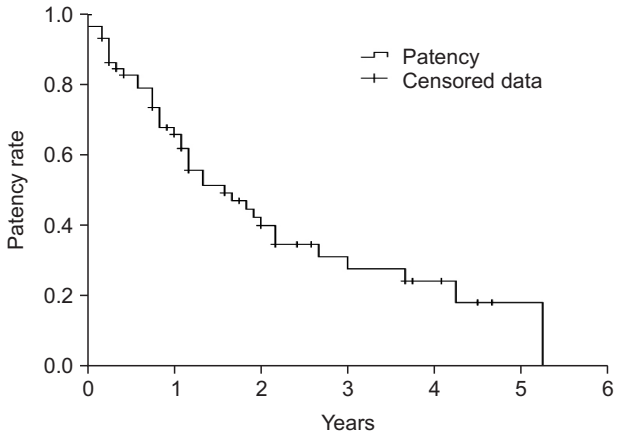

Fig. 1. Primary patency rate of lower extremity grafts for hemodialysis.

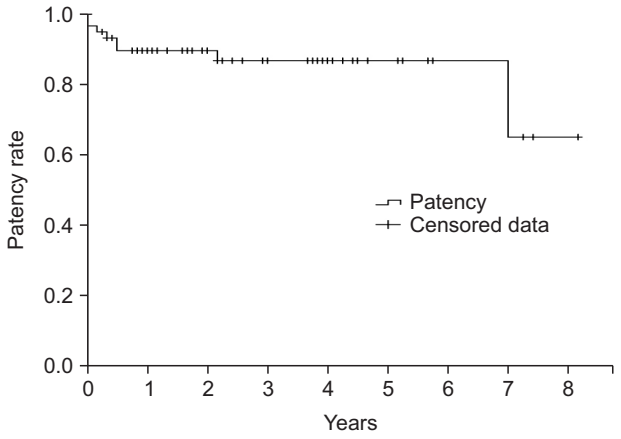

Fig. 2. Secondary patency rate of lower extremity grafts for hemodialysis.

failure (CRF) who require hemodialysis. According to the National Kidney Foundation Kidney Disease Outcomes Quality Initiative and the European Best Practices Guidelines for Vascular Access, the first choice for a dialysis access conduit is an AVF in the upper extremity [6,7]. In the absence of suitable veins or after exhaustion of the superficial veins in the upper extremity, the next best type of access is a prosthetic AVG in the arm. However, in light of the ever increasing number of patients with CRF, the aging dialysis population and their prolonged longevity, surgeons have increasingly encountered difficult access problems, such as exhausted upper extremity access sites due to various reasons (infection, steal syndrome, repeated thrombotic occlusion, etc.) and central vein occlusion. In these situations, an available option to create a permanent vascular access site would be in the lower extremity. Our study included 54 patients with both central venous occlusion and 6 patients with exhausted upper extremity access sites.

Initial experiences with enforcing the hemodialysis access to the lower extremity were discouraging because of high infection rate and associated major limb amputation [8,9]. Presently, lower extremity AVGs are created as a last resort, for patients who have failure of their upper extremity sites. With the introduction and use of PTFE as a material in manufacturing prosthetic hemodialysis access products and with improvements in surgical techniques and dialysis care, the lower extremity has received renewed attention as a valuable hemodialysis access site in our institution. In 1980, Morgan et al. [10] described their experience with hemodialysis access in the lower extremity. Twenty-seven infections eventually occurred. A compromise in surgical procedures was necessary due to the patients' precarious medical status. The clinical outcomes were successful in most instances but the overall mortality was 18% and the amputation rate was 22%. They concluded that the high incidence of infection in the groin confirmed the original impressions that this site should not be used if another is available. The disappointing results led to the near complete non-use of the lower limb for hemodialysis access during the 1980s.

Several recently published studies have reported the outcomes of lower extremity AVG and their conclusions differ dramatically from earlier results. Some studies suggested that thigh AVG is safe, with excellent long-term patency [11-13], while others consider it a procedure of last resort, because of the high rate of complications such as infection and arterial steal.

In 1998, Korzets et al. [5] reported a 1-year secondary patency rate of 73%, with infection rate of only 5%. This study concluded that lower extremity AVG may be preferred to upper extremity AVGs. In 2002, Tashjian et al. [14] reported a one year primary patency rate of 71% and a secondary patency rate of 83% in their lower extremity prosthetic AVGs placed between 1990 and 1998. The incidence of infection in their series was 22%.

In 2010, Geenen et al. [3] reported a 1, 2 and 5 year primary patency rate of 53.9%, 36.9% and 19.3%, and a secondary patency of 75.3%, 63.8% and 50.6%, respectively; with an infection rate of 27% and limb ischemia of 1.3%. They concluded that lower extremity AVG can be a suitable alternative to upper extremity vascular access.

In contrast, there were also reports of relatively poor outcomes with lower extremity AVG. In 2000, Vogel et al. [15] reported a 62% graft survival rate at one year and a 46% infection rate with lower extremity AVG for hemodialysis (n=134). Cull et al. [4] reported only 34% primary patency rate and a 68% secondary patency rate at 1 year with 41% graft infection. In 2006, Englesbe et

https://doi.org/10.5758/vsi.2016.32.4.180

Table 3. Summary of results of other studies

Author, year		Lower extremity	Upper extremity	P-value
Miller et al., 2003 [17]	Technical failure	12.7%	5.8%	0.046
	Total intervention rate (per-graft year of follow-up)	2.15	1.70	0.40
	Access loss due to infection	11.1%	5.2%	0.07
Akoh et al., 2005 [18]	Primary failure	17%	15%	0.188
	Graft survival (mo)	36	32	0.1959

al. [16] reported 41%, 26% and 21% secondary patency rate at one, two and three years, respectively. Infection was the ultimate cause of graft loss in eight patients. They concluded that some of these complex patients who had exhausted their upper extremity hemodialysis options with poor lower extremity AVG placement should be considered for long term catheter-based access.

Infection occurred in 15% and steal syndrome of the ipsilateral extremity occurred in only 3% of our patients. Our 1, 2, 3, and 5 year primary patency rates were 66%, 40%, 27% and 18%, respectively and 1, 3, 5, and 7 year secondary patency rates were 90%, 87%, 87% and 65%, respectively. The patency rates in our series were somewhat higher than in other studies. This may be due to the small patient population enrolled and some patients receiving multiple interventions in our study.

The more prohibitive reported shortcomings associated with lower extremity vascular access are infection and ischemic complications. The incidence of clinically significant infection in our study was 15%. Infection remains the most common reported complication after lower extremity AVG placement and this complication is one of the major reasons upper extremity AVGs are favored in vascular access guidelines [6,7]. Our ability to salvage 2 (22%) of the 9 infected AVGs by means of partial excision and interposition graft procedure prevented loss of the access site and dialysis was continued without the need for a longer-term tunneled dialysis catheter. Geenen et al. [3] reported successful outcome with this technique for infected lower extremity AVG in 15 (37%) cases. Cull et al. [4] also reported the use of segmental resection for salvaging infected grafts, but the overall success rate was not mentioned.

The infection rate in our study was lower than in other studies. Meticulous perioperative wound care and careful tunneling to prevent hematoma may be some of the reasons for the better outcome.

Lower limb ischemia is the other major complication seen with the use of lower extremity AVG. Lower limb ischemia occurred in 2 (3%) patients in our study, which is lower than the incidence of ischemic complications in another study (6%, 11%) [5,13]. One patient was managed by means of interposition grafting to the proximal artery. The other patient required ligation of the graft because of severe symptoms after the operation. This particular patient had peripheral arterial disease affecting both lower extremities. The preoperative examination was fine. Since both central vein accesses were occluded, a lower extremity AVG was made because it was deemed that there was no other choice at that time.

Primary failure, defined as technical failure or inability to use the graft within 30 days after placement, ranged from 3% to 17% of thigh grafts placed [4,5,11,13,15]. Two studies that compared the primary failure of lower extremity grafts to that of upper arm grafts reported different results. In 2003, Miller et al. [17] reported that the technical failure rate was approximately twice as high for lower extremity grafts compared with upper extremity grafts (12.7% vs. 5.8%, P=0.046). Two years later, Akoh et al. [18] reported an overall primary failure rate of 20.8% (upper extremity grafts 46% and lower extremity grafts 17%). The main causes of primary failure in their study were graft infection and early thrombosis. Our primary failure rate was 7 out of 60 cases (distal ischemia in 2 patients, infection in 3 patients and early thrombosis in 2 patients). Similar to upper arm AVG, thrombosis was the major reason for lower extremity graft intervention and failure. About 25-85% of grafts had at least one episode of thrombosis [13,14,17,19,20]. Miller et al. [17] reported the frequency of angioplasty (0.28 vs. 0.57 per year), thrombectomy (1.58 vs. 0.94 per year), surgical revision (0.28 vs. 0.18 per year), and total intervention rate (2.15 vs. 1.70 per year) in thigh versus upper extremity grafts (Table 3) [17,18]. The major cause of graft failure in our study was stenosis (at the graft to GVA site in particular) followed by thrombosis. About 36.6% of the lower extremity grafts developed a thrombosis at least once. The median intervention rate in our study was 0.81 per patient year.

CONCLUSION

Sixty lower extremity AVGs were placed in 57 patients

in our hospital during the study period. A lower extremity AVG can be a viable option when a patient has either central vein occlusion in both of their upper extremities or has central vein occlusion in one upper extremity along with contralateral upper limb amputation, infection or steal syndrome with no useable veins. We were able to achieve good primary and secondary patency rates comparable to the results of others. Lower extremity AVG is a suitable and durable procedure for patients who have no usable upper extremity vessels for operation.

REFERENCES

1) Brescia MJ, Cimino JE, Appel K, Hurwich BJ. Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. N Engl J Med 1966;275:1089-1092.
2) Harish A, Allon M. Arteriovenous graft infection: a comparison of thigh and upper extremity grafts. Clin J Am Soc Nephrol 2011;6:1739-1743.
3) Geenen IL, Nyilas L, Stephen MS, Makeham V, White GH, Verran DJ. Prosthetic lower extremity hemodialysis access grafts have satisfactory patency despite a high incidence of infection. J Vasc Surg 2010;52:1546-1550.
4) Cull JD, Cull DL, Taylor SM, Carsten CG 3rd, Snyder BA, Youkey JR, et al. Prosthetic thigh arteriovenous access: outcome with SVS/AAVS reporting standards. J Vasc Surg 2004;39:381-386.
5) Korzets A, Ori Y, Baytner S, Zevin D, Chagnac A, Weinstein T, et al. The femoral artery-femoral vein polytetrafluoroethylene graft: a 14-year retrospective study. Nephrol Dial Transplant 1998;13:1215-1220.
6) Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis 2006;48 Suppl 1:S176-S247.
7) Tordoir J, Canaud B, Haage P, Konner K, Basci A, Fouque D, et al. EBPG on Vascular access. Nephrol Dial Transplant 2007;22 Suppl 2:ii88-ii117.
8) Mandel SR, McDougal EG. Popliteal artery to saphenous vein vascular access for hemodialysis. Surg Gynecol Obstet 1985;160:358-359.
9) Connolly JE, Brownell DA, Levine EF, McCart PM. Complications of renal dialysis access procedures. Arch Surg 1984;119:1325-1328.
10) Morgan AP, Knight DC, Tilney NL, Lazarus JM. Femoral triangle sepsis in dialysis patients: frequency, management, and outcome. Ann Surg 1980;191:460-464.
11) Khadra MH, Dwyer AJ, Thompson JF. Advantages of polytetrafluoroethylene arteriovenous loops in the thigh for hemodialysis access. Am J Surg 1997;173:280-283.
12) Bhandari S, Wilkinson A, Sellars L. Saphenous vein forearm grafts and gortex thigh grafts as alternative forms of vascular access. Clin Nephrol 1995;44:325-328.
13) Taylor SM, Eaves GL, Weatherford DA, McAlhany JC Jr, Russell HE, Langan EM 3rd. Results and complications of arteriovenous access dialysis grafts in the lower extremity: a five year review. Am Surg 1996;62:188-191.
14) Tashjian DB, Lipkowitz GS, Madden RL, Kaufman JL, Rhee SW, Berman J, et al. Safety and efficacy of femoral-based hemodialysis access grafts. J Vasc Surg 2002;35:691-693.
15) Vogel KM, Martino MA, O'Brien SP, Kerstein MD. Complications of lower extremity arteriovenous grafts in patients with end-stage renal disease. South Med J 2000;93:593-595.
16) Englesbe MJ, Al-Holou WN, Moyer AT, Robbins J, Pelletier SJ, Magee J, et al. Single center review of femoral arteriovenous grafts for hemodialysis. World J Surg 2006;30:171-175.
17) Miller CD, Robbin ML, Barker J, Allon M. Comparison of arteriovenous grafts in the thigh and upper extremities in hemodialysis patients. J Am Soc Nephrol 2003;14:2942-2947.
18) Akoh JA, Sinha S, Dutta S, Opaluwa AS, Lawson H, Shaw JF, et al. A 5-year audit of haemodialysis access. Int J Clin Pract 2005;59:847-851.
19) Schild AF, Perez E, Gillaspie E, Seaver C, Livingstone J, Thibonnier A. Arteriovenous fistulae vs. arteriovenous grafts: a retrospective review of 1,700 consecutive vascular access cases. J Vasc Access 2008;9:231-235.
20) Salimi J. Patency rate and complications of vascular access grafts for hemodialysis in lower extremities. Saudi J Kidney Dis Transpl 2008;19:929-932.

https://doi.org/10.5758/vsi.2016.32.4.180