

Successful Use of Arteriovenous Graft for Hemodialysis Access After Left Ventricular Assist Device Placement



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Kidney replacement therapy is required in up to one-third of patients after left ventricular assist device (LVAD) placement. A subset of these patients requires long-term maintenance hemodialysis and therefore needs durable vascular access but the ideal access in such patients has not been established. We present a series of 3 patients in whom arteriovenous grafts (AVGs) were successfully used for long-term kidney replacement therapy after LVAD placement. The maximum time from AVG placement to first successful AVG use was 40 days, and the longest AVG use duration was more than 2 years. 2 patients required AVG excision due to infection but both had successful placement of a second AVG. Total time on kidney replacement therapy was 993, 1,055, and 956 days for the 3 cases, of which dialysis catheter use was required for only 23%, 6.5%, and 27%, respectively. These cases suggest that AVG placement is a viable option for dialysis access in patients with LVADs.

Complete author and article information provided before references.

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INTRODUCTION

The use of left ventricular assist devices (LVADs) in the treatment of advanced heart failure has rapidly increased, with more than 20,000 LVADs implanted during the last decade.^{1,2} Kidney replacement therapy (KRT) is required in 11% to 33% of patients after LVAD implantation, and a subset of these patients require long-term KRT.³ Infectious concerns and the nearly exclusive use of continuous flow (CF)-LVADs, with minimal to no arterial pulsatility present, pose several unique concerns for maintenance dialysis, including the ideal choice of vascular access.^{4,5} Although the long-term use of tunneled hemodialysis catheters carries the risk for catheter-related bloodstream infection and associated seeding of the device,⁴ it remains unclear whether arteriovenous fistula (AVF) or arteriovenous graft (AVG) creation provides a viable alternative due to potential limitations arising from CF-LVAD physiology and the creation of a higher cardiac output state.^{3,5} Previous publications have provided limited evidence suggesting that AVF creation can be successful in patients with LVADs⁶⁻⁸ but only 1 case of successful use of an AVG has been described.⁹ We present a series of 3 patients with successful AVG insertion and use after CF-LVAD implantation.

CASE REPORTS

The details of each case are summarized in [Table 1](#). In each case, preoperative vein mapping was performed using duplex sonography, and an AVG was chosen for access due to the dimensions of the vasculature. For patients with LVADs requiring durable hemodialysis access, an AVG was pursued over an AVF unless venous diameter exceeded 3 mm and the quality of both the artery and vein were excellent. All AVGs were polytetrafluoroethylene. All patients were clinically stable overall and had no signs of critical illness at the time of AVG placement.

This retrospective data review was approved by the Institutional Review Board of Columbia University Irving Medical Center. Informed consent could not be obtained because all patients were deceased at the time of manuscript preparation, and attempts to contact next of kin (by author K.T.) were not successful.

Case 1

A man in his 60s without known chronic kidney disease (CKD) developed oliguric acute kidney injury (AKI) requiring KRT initiation 2 days after HeartMate 3 (Abbott) LVAD implantation as destination therapy. He did not exhibit subsequent kidney function recovery, and the decision was made to place durable hemodialysis access. A brachiobasilic loop AVG was placed 53 days after LVAD implantation. The AVG was successfully cannulated for hemodialysis 36 days later. His course was subsequently complicated by bacteremia caused by *Streptococcus bovis* attributed to colonic polyps. The bacteremia resolved 3 days after ceftriaxone therapy initiation, but the development of an infected AVG pseudoaneurysm required a total of 6 weeks of ceftriaxone treatment and AVG excision 458 days after creation (422 days after the first successful use). A contralateral brachiobasilic loop AVG was placed 94 days later and used 46 days after insertion. He developed AVG thrombosis in the setting of atrial fibrillation, requiring a thrombectomy 98 days after the second AVG insertion. The second AVG continued to function until 344 days after first use, when the patient died after transition to palliative care. He required a dialysis catheter for 23% of his approximately 3 years receiving KRT ([Fig 1](#)).

Case 2

A man in his 60s with CKD stage 3b developed septic shock complicated by oliguric AKI approximately 16 months after HeartWare (Medtronic) LVAD implantation as a

Table 1. Characteristics of Cases

	Patient A		Patient B	Patient C	
	AVG 1	AVG 2		AVG 1	AVG 2
Age at AVG placement, y	60s		60s	60s	
Body mass index, kg/m ²	27.2		27.2	24.8	
Diabetes mellitus	Yes		Yes	No	
Atrial fibrillation	Yes		Yes	Yes	
Cause of heart failure	ICM		ICM	NICM	
Type of VAD	HM3		HVAD	HMII	
Pre-AVG venous thrombosis	None		None	Multiple	
Time from LVAD implant to AVG placement, d	53	605	539	91	321
Pre-AVG vascular dimensions					
Upper arm cephalic vein, mm	2.4 (proximal), 2.9 (mid), 2.6 (distal)	—	—	2.5 (proximal), 2.5 (mid)	—
Basilic vein, mm	3.3 (proximal), 3.7 (mid)	—	2	4.9 (proximal), 3 (mid)	—
Proximal brachial artery, mm	—	—	4	6.6	—
Mid brachial artery, mm	4.4	—	4	6.4	—
Proximal radial artery, mm	—	—	3	—	—
Mid radial artery, mm	—	—	3	—	—
Distal radial artery, mm	—	—	4	4.1	—
Distal ulnar artery, mm	—	—	1	3.1	—
Ipsilateral devices	AICD	TDC	PICC	PICC	TDC
Procedures required before AVG use	None	None	Angioplasty ×1	Revision	None
Time from AVG placement to first successful use, d	36	46	32	40	10

Abbreviations: AICD, automated implantable cardioverter defibrillator; AVG, arteriovenous graft; HM3, HeartMate 3; HMII, HeartMate II; HVAD, HeartWare ventricular assist device; ICM, ischemic cardiomyopathy; LVAD, left ventricular assist device; NICM, nonischemic cardiomyopathy; PICC, peripherally inserted central catheter; TDC, tunneled dialysis catheter; VAD, ventricular assist device.

bridge to transplantation and did not exhibit subsequent kidney function recovery. A brachiocephalic loop AVG was inserted 37 days after KRT initiation. Balloon angioplasty of the AVG was performed 30 days later for stenosis at the arterial anastomosis. The AVG was successfully used 2 days later. He did not require subsequent vascular access procedures and had no access or bloodstream infections. The AVG functioned without complications for approximately 2½ years until dialysis was withdrawn when goals of care changed to palliation and hospice. The patient required a dialysis catheter for 6.5% of his approximately 3 years receiving KRT (Fig 1).

Case 3

A man in his 70s with CKD stage 3b developed oliguric AKI requiring KRT 3 days after HeartMate II LVAD implantation as destination therapy and did not exhibit subsequent recovery of his kidney function. Medical history included provoked upper- and lower-extremity deep venous thromboses. A brachiocephalic loop AVG was placed 91 days after LVAD implantation. The first cannulation attempt 21 days later was unsuccessful due to the development of hematoma requiring surgical evacuation and revision of the AVG. The AVG was successfully used 40 days after initial insertion. His course was subsequently complicated by bacteremia caused by *Enterococcus faecalis* and *Pseudomonas aeruginosa* attributed to deep LVAD driveline

infection. His bacteremia resolved after 3 days of treatment with piperacillin/tazobactam, but his driveline infection required additional treatment with meropenem (6 weeks total) and an extended course of cefepime treatment. His AVG was excised 79 days after initial insertion out of concern for infectious seeding. An ipsilateral brachiocephalic loop AVG was placed 151 days later, with the first successful use for hemodialysis 10 days later. Suction thrombectomy with balloon angioplasty was performed

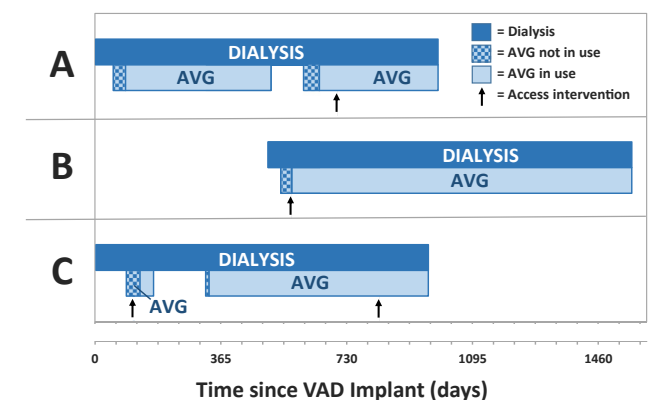


Figure 1. Timeline of arteriovenous graft (AVG) placement and use. Abbreviation: VAD, ventricular assist device.

522 days after insertion due to AVG thrombosis. This AVG functioned until the patient's death approximately 2 years after its first use. The patient required a dialysis catheter for 27% of his 2¹/₂ years receiving KRT (Fig 1).

DISCUSSION

The increasing incidence of LVAD implantation combined with the high prevalence of CKD and postoperative AKI have resulted in the need for maintenance hemodialysis in a subset of these patients. Although hemodialysis can be well tolerated by patients with LVADs, the best vascular access for long-term dialysis in these patients is unclear due to several observed and theoretical concerns.^{5,10} We describe the successful use of AVGs for long-term hemodialysis access in 3 patients with LVADs, all of whom required dialysis catheter use for <30% of their time receiving dialysis.

Although tunneled dialysis catheters can be used immediately after insertion, they carry the risk for catheter-related bloodstream infections and central venous stenosis.⁵ This is especially relevant for patients with LVADs given a high baseline bloodstream infection rate.¹¹ Bloodstream infections are the second most common cause of infection in patients with LVADs after driveline infections and are of particular concern given the risk for seeding hardware. In a study of 101 episodes of infection in 78 patients with LVADs, catheter-related or -associated infection accounted for most bloodstream infections not directly attributable to LVAD hardware.⁴ The use of an AVG or AVF is therefore appealing to potentially mitigate this risk for infection.

The benefits and disadvantages of AVFs versus AVGs in patients with LVADs are largely theoretical and have not been studied directly. Concerns with AVFs include high-output heart failure and failure of access maturation due to vasculature limitations, lack of pulsatile flow, and lower blood pressure.¹² Though any arteriovenous shunt can lead to high-output failure, this risk theoretically increases over time in patients with AVFs due to ongoing maturation and remodeling in AVFs.¹³ Endothelial dysfunction in patients with heart failure and the association of poor vasoreactivity with the development of cardiovascular disease are both well established and pose a theoretical risk to AVF creation and maturation.¹² Amir et al¹² compared the effects of continuous flow versus pulsatile flow on peripheral vasoreactivity and found superior flow-mediated dilation in the setting of pulsatile flow. The difference in brachial artery diameter did not significantly differ in the 2 populations. To date, 3 case series cumulatively report AVF placement after LVAD implantation in 6 patients.⁶⁻⁸ Of these, 3 patients required access intervention before first use, and time to first successful AVF use ranged from 39 to 149 days after creation, with half the cases requiring more than 3 months before first use. Additionally, 5 patients required intervention after first successful AVF use. Among the 3 patients we describe in this report, maximum time to the first successful AVG use was 40 days after placement despite 2 AVGs requiring intervention before first use. Combined with a recent report of

successful AVG cannulation 15 days after placement in a patient with an LVAD, these cases suggest that AVGs may expedite dialysis catheter removal.⁹

However, AVG placement carries the risks associated with foreign body placement, including bacterial colonization and infection. In the general dialysis population, the incidence of infection in upper-extremity AVGs is up to 10 times higher than with AVFs; however, both these types of access carry significantly lower risk for infection compared with dialysis catheters.¹⁴⁻¹⁶ Two of the patients presented here required AVG excision and a second AVG in the setting of infection, neither of whom developed infections after the second AVG placement. Catheter time in both patients was increased due to the duration of antibiotic treatment. Unfortunately, a comparison of total catheter time between AVF and AVG use cannot be made at this time, and the overall risk for bloodstream infection following AVG versus AVF placement in patients with LVADs is not known.

In conclusion, an AVG appears to be a viable option for long-term hemodialysis access in patients requiring long-term KRT after LVAD implantation, with the benefit of shortening dependence on dialysis catheter use, but potentially with an elevated risk for access infection compared with historical reports of AVFs.

ARTICLE INFORMATION

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