Axillary loop grafts for hemodialysis access: Midterm results from a single-center study

Elixène Jean-Baptiste, MD, Réda Hassen-Khodja, MD, Pierre Haudebourg, MD, Serge Declemy, MD, Michel Batt, MD, and Pierre Jean Bouillanne, MD, Nice, France

Purpose: This study reports our midterm results with arteriovenous axillary loop grafts (AVALG) and evaluates their role in construction of vascular access for patients on chronic hemodialysis.

Methods: The clinical data of 27 patients who underwent construction of an AVALG for hemodialysis access at our institution between July 2002 and December 2006 were analyzed retrospectively. Outcome measures included graft patency, the complication rate, and the frequency and morbidity of secondary procedures after AVALG creation. The Kaplan-Meier method was used to calculate the primary and secondary patency curves.

Results: AVALG was constructed as the first access procedure in eight patients: five patients with no suitable vein to construct an adequate angioaccess on the upper limbs, and three patients with elbow and forearm arteritis. The 19 other patients had all had two to five failed prior vascular accesses leading to exhaustion of venous access sites on the upper extremities (18 cases), or a steal syndrome (one case). No postoperative death occurred, but four patients died of causes unrelated to the intervention between the second and the tenth postoperative months. The mean follow-up was 15 months (range, 2-48 months). The primary patency rate at 12 months and the secondary patency rate at 18 months were 51% and 80%, respectively. Infection (three cases), thrombosis (seven cases), and stenosis of the outflow vein (two cases) were the main complications, occurring in 10 of the 27 patients (41%). Twelve secondary procedures were performed in these 10 patients with little additional morbidity. Five of the 27 patients developed irreversible AVALG occlusion leading to access loss: two patients with concomitant graft infection and three patients with a history of subclavian vein catheterization.

Conclusion: AVALG may represent a supplementary option for chronic hemodialysis patients with vascular steal or inadequate upper extremity venous access sites. (J Vasc Surg 2008;47:138-43.)

The number of patients with end-stage renal disease (ESRD) requiring hemodialysis is constantly rising worldwide.1 In Europe, over 25% of all hospital admissions for ESRD are for the construction or maintenance of a patent vascular hemodialysis access.2 Arteriovenous fistulas constructed from autogenous upper extremity veins are the vascular access of choice as they offer the best patency and lowest complication rates.3 While the life expectancy of patients on chronic dialysis continues to lengthen,1,4 the durability of these vascular accesses is limited. Repeat fistula construction at different levels of the upper extremity (wrist, forearm, upper arm) is often necessary and can ultimately result in exhaustion of autogenous vascular access sites. Use of a synthetic prosthesis to construct on the upper arm an arteriovenous brachial-axillary graft or on the forearm a brachial-brachial loop graft is currently the recommended treatment alternative for patients who have exhausted all native fistulas access options.3,8 However, such grafts have lower patency rates and shorter lifetimes than autogenous arteriovenous fistulas.3 Recourse to lower extremity veins6 or indwelling central venous catheters7,8 often becomes necessary for the survival of patients on chronic hemodialysis. However, the morbidity of these procedures remains elevated. Construction of a loop graft from one axillary artery to the ipsilateral axillary vein may represent a supplementary alternative for these patients.9 To our knowledge, no series dealing solely with these arteriovenous axillary loop grafts (AVALG) has been published to date. The purpose of this study was to report our midterm results with AVALG and to evaluate their role in the creation of vascular accesses for patients requiring chronic hemodialysis.

MATERIAL AND METHODS

Between July 2002 and December 2006, 435 consecutive procedures for creation of a hemodialysis vascular access were performed in our vascular surgery department. Demographic data for all patients and the types of access constructed were recorded in a computerized database. For study purposes, all patients who had AVALG construction during this period were identified and their charts were reviewed. The main reason for selection of an arteriovenous axillary loop configuration was mentioned in the individual operative reports. Demographic data, cardiovascular risk factors, and the cause of ESRD were noted in each clinical file. The number, the locations, and the type of any previous vascular accesses were also recorded for each patient. All technical details, including AVALG construction, the duration of the procedure, and the material used were also noted.
Configuration of axillary loop grafts for hemodialysis.

All AVALG were constructed by one of the vascular surgeons in our department using a standard protocol. All patients underwent preoperative arterial Doppler ultrasound to rule out a proximal lesion on the axillary-subclavian arterial axis. Likewise, venous Doppler ultrasound was performed for all patients to rule out stenosis or occlusion of the homolateral subclavian vein. Phlebography was performed in selected patients to rule out a central venous lesion. All patients were operated under general anesthesia in dorsal decubitus with the upper extremity abducted on the operated side. A single dose of cefazolin (2000 mg) was administered to every patient just prior to the skin incision. Figure 1 presents the usual configuration of AVALG performed in our department. For all patients, a 7-cm long transverse incision was made 2 cm below the clavicle. A loop was constructed in a subcutaneous tunnel, superficial to the pectoralis major muscle; two intermediate incisions were made on either side of the top of the loop (Figure 1). Three minutes before arterial clamping, a bolus of 50 IU/kg of unfractionated heparin was administered to all patients. The prosthesis consisted in a tapered (4-7 mm diameter) polytetrafluoroethylene tube (PTFE, Vascugraft B. BRAUN, Berlin, Germany) with a standard, nonreinforced wall. We have used a tapered 4-7 mm PTFE tube with the 4 mm tip implanted on the axillary artery so that we could calibrate the arterial anastomosis to avoid high flow rate problems. Conversely, the 7 mm extremity was implanted on the axillary vein where anastomotic stenosis is more likely to occur. Arterial anastomosis was always performed first. The 4-mm PTFE segment was implanted end-to-side on the antero-superior aspect of the axillary artery using a running polypropylene 6-0 suture. The transpectoral graft trajectory towards the subcutaneous tissue was cautiously fashioned to avoid kinking. End-to-side anastomosis to the axillary vein was performed last.

This anastomosis was always placed laterally to the arterial one (Figure 1) in order to direct the arteriovenous flow clockwise, towards the heart, and thus, possibly limit postoperative arm edema. Presence of a thrill in the AVALG at unclamping was systematically verified. The incisions were closed in two layers with aspiration-drainage placed at the level of the subclavian access. Postoperatively, no antiplatelet or anticoagulant treatment was added to the drugs the patient had been taking before the intervention.

During follow-up, the AVALG was monitored by both the treating nephrologists and a vascular surgeon. Clinical examination was performed by the surgeon before hospital discharge, after 1 and 3 months, and then every 6 months. The nephrologists monitored blood flow in the loop graft by Doppler ultrasound and the compression time required for hemostasis after hemodialysis. Flow assessments by dilution techniques were not performed because they were not available in our dialysis referring centers during the study period. Doppler ultrasound was performed whenever anomalies were detected clinically (pulsatility, disappearance of the thrill, upper extremity edema), in case of poor hemodialysis performance or in case of prolongation of the compression time required at the end of the hemodialysis. Besides, Doppler ultrasound was systematically performed after 3 and 6 months, then every year in the absence of any complication. All complications, their date of onset, the treatment administered, and the result of management were recorded systematically. In case of permanent thrombosis or occlusion of the axillary loop, the alternate vascular accesses used next for hemodialysis were noted, as was the cause of the thrombosis or occlusion.

The main purpose of this retrospective study was to determine the primary and secondary patency rates of AVALG in patients on chronic hemodialysis. The secondary aims were evaluation of the rates of short- and midterm complications related to subclavian loops, identification of causes leading to permanent AVALG access loss, and assessment of the frequency and morbidity of secondary procedures in patients with AVALG.

Statistical analysis was performed with StatView software (SAS Institute, Inc., Cary, NC; version 5.0). Nominal variables were expressed as a number and a percentage of patients. Continuous variables were expressed as the mean ± standard deviation or the range for non-Gaussian distributions. The Kaplan-Meier method was used to calculate the primary and secondary patency curves. Patency rates were estimated unreliable according to Sidawy et al when standard error exceeds 10%.

RESULTS

From July 2002 to December 2006, among 435 vascular accesses for hemodialysis performed in our department, 27 AVALG were constructed on 27 patients: 15 men and 12 women. Mean age was 73 years (51-92 years). Hypertension, diabetes, and severe coronary artery disease were the main comorbid factors present in 17 (63%), 8 (30%), and 8 (30%) patients, respectively. The main causes of ESRD in this cohort are listed in the Table. These 27
patients had been on chronic hemodialysis for a mean of 16 months (range, 0-95 months), and they all underwent arterial and venous Doppler ultrasound of the upper extremities preoperatively. Phlebography was performed to rule out central venous stenosis before AVALG construction on two patients with inconclusive Doppler findings. None of the 27 patients had preoperative upper limb arteriography. The AVALG was created as the initial access site in eight patients: five patients with no suitable vein to construct an adequate angioaccess on the upper limbs as evidenced by preoperative Doppler ultrasound (venous obstruction, or multiple vein stenoses), and three patients with elbow and forearm arteritis (severely calcified arterial wall, arterial stenosis or arterial occlusion at Doppler examination). For the other 19 patients, a total of 38 different hemodialysis access sites (between two and seven prior accesses per patient) had been previously constructed and failed, leading to exhaustion of venous access sites on the upper extremities (18 cases) or to a steal syndrome (one case). These patients had had: 10 brachial-cephalic fistulas, 14 brachial-axillary grafts, 4 brachial-basilic fistulas, 8 wrist cephalic-radial fistulas, and 2 lower extremity arteriovenous fistulas constructed using the superficial femoral vein. On the whole, the axillary site was selected because of inadequate access options for venous reasons in 23 patients and for upper extremity arteritis in three patients. In the last patient, the loop was constructed after ligation of a homolateral brachial-cephalic fistula responsible for vascular steal syndrome with severe ischemia and several fingers necrosis. This patient showed no signs of recurrent ischemia after AVALG construction.

The AVALG were constructed on the right side in 24 patients and on the left side in three patients. The mean operating time was 93 minutes (range, 60-150 minutes). The mean flow in the graft was 1.1 l/min (range, 0.5-1.8 l/min.). The mean duration of the hospital stay was 2.6 days (range, 2-4 days). No postoperative deaths occurred, but one 61-year-old man developed acute lung edema in the immediate postoperative period that evolved favorably. There was no additional operative morbidity.

No patients were lost to follow-up (mean 15 months; range, 2-48 months). Four patients (15%) died of causes unrelated to the intervention (two in the second month, one in the fourth month, and one in the tenth postoperative month). Among these four deaths, three patients died before their loop could be used. During follow-up, 10 of the 27 patients (41%) developed one or more complications related to their axillary loop: postanastomotic stenosis on the outflow vein in 2 patients, thrombosis of the subclavian vein downstream of the loop in 4 patients, graft occlusion in 7 patients, and AVALG infection in 3 patients. No case of false aneurysm was diagnosed. The primary patency rate at 12 months was 51% (Fig. 2). Both cases of postanastomotic stenosis of the outflow vein were revealed by upper extremity edema associated with poor hemo dialysis performance. The stenosis in these two patients was successfully treated by angioplasty of the outflow vein and stent placement. Two of the four patients who developed thrombosis of the downstream subclavian vein also had prosthetic obliteration; the other two still had a patent loop. One of these patients with a patent loop presented with upper extremity edema; the other presented a clinical picture of severe upper extremity venous ischemia associated with edema. Endovascular stent placement in a subclavian vein of these last two patients restored patency. The seven cases of graft occlusion were associated with thrombosis of the downstream subclavian vein (two cases), anastomotic stenosis (three cases), or graft infection (two cases). Neither of the two occluded grafts secondary to thrombosis of the downstream subclavian vein was salvageable. The anastomatic stenosis was located on the venous

| Table. Etiology of chronic end-stage renal disease |
| Cause | N | % |
| Diabetic nephropathy | 7 | 26% |
| Nephroangiosclerosis | 3 | 11% |
| Renal polycystosis | 2 | 7% |
| Bilateral nephrectomy for cancer | 2 | 7% |
| Renal agenesis with fibromyxositis | 1 | 4% |
| Chronic interstitial nephropathy | 1 | 4% |
| Toxic nephropathy | 1 | 4% |
| Monoclonal gammopathy | 1 | 4% |
| Undetermined | 9 | 33% |
| Total | 27 | 100% |

| Time (months) | 0 | 1 | 6 | 12 | 18 | 24 | 36 |
| N at risk | 27 | 26 | 15 | 9 | 3 | 3 | 1 |
| Primary patency (PP) | 100% | 96% | 75% | 51% | 51% | 51% | 34% |
| Standard error for PP | 0% | 4% | 9% | 10% | 12% | 12% | 16% |
| N at risk | 27 | 26 | 19 | 13 | 6 | 6 | 4 |
| Secondary patency (SP) | 100% | 96% | 87% | 87% | 80% | 80% | 67% |
| Standard error for SP | 0% | 4% | 7% | 7% | 9% | 10% | 14% |

Fig 2. Kaplan Meier curves of primary and secondary patency rates. Standard error exceeds 10% after 12 months for primary patency. Standard error exceeds 10% after 24 months for secondary patency.
segment of the loop in two patients and on the arterial segment in one patient. Both venous segment stenoses were successfully treated by angioplasty and stent placement at the site of the venous lesion after surgical thrombectomy at the level of the loop. The patient with anastomotic stenosis of the arterial loop segment underwent surgical thrombectomy and angioplasty without stent placement. This was followed by early and irreversible recurrence of thrombosis. The three cases of AVALG infection were related to needle site infection (two cases occurring at 9 months and 24 months, respectively, from the initial operation) or to operative wound infection (one case). Of those three patients who developed AVALG infection, the one with operative wound infection underwent removal and replacement of the entire AVALG 2 months postoperatively using a silver-coated polyester prosthesis (InterGard Silver, La Ciotat, France). This second loop became occluded 3 months later and could not be salvaged. The two other patients who developed an infection were managed by replacement of the infected segment of the PTFE graft with a silver-coated polyester prosthesis (InterGard Silver). In one of these two patients, the polyester loop was still patent after a follow-up of 36 months. In the other patient, infection recurred 3 months later and was retreated in the same manner; this new loop became permanently occluded 9 months after the second intervention. In overall, 12 secondary procedures were performed on the axillary loops of the 10 patients who developed complications. However, five patients had irreversible occlusion leading to permanent loss of the AVALG access. The secondary patency rate at 18 months was 80% (Fig. 2). Among the five patients who developed permanent axillary loop occlusion, we could note a concomitant graft infection (two patients), a history of subclavian vein catheterization (three patients), or an anastomotic stenosis of the arterial loop segment (one patient). Alternate temporary hemodialysis was performed on these five patients using temporary jugular catheters (two cases) or temporary femoral catheters (three cases). In the midterm, two of those five patients underwent placement of an indwelling Cauna catheter. Two other patients had successful construction of another vascular hemodialysis access: one arteriovenous brachial-brachial loop and one arteriovenous femoral-femoral fistula using the superficial femoral vein. Peritoneal dialysis was instituted for the last patient.

DISCUSSION

With a 12-month primary patency rate of 51% and a secondary patency rates of 80% at 18 months, our results reveal that AVALG permit satisfactory hemodialysis when constructed in selected patients. The potential limitations of this study are those of any retrospective study without a control group and its relative small sample size. Nevertheless, our secondary patency rate was markedly better than the minimum recommended by the National Kidney Foundation (70% secondary patency at 1 year). The use of endovascular techniques, associated in the most severe cases with surgical thrombectomy, considerably improves the lifetime of AVALG used for hemodialysis with low morbidity.

After a mean follow-up of 15 months, the majority of axillary loop complications in our patients corresponded to thrombosis. Anastomotic stenosis secondary to myointimal hyperplasia, subclavian vein occlusion, or stenosis of the outflow vein were diagnosed and corrected in most of the patients who developed AVALG thrombosis. The difference in compliance between the vein and the prosthesis, flow turbulence in the vein, the vascular trauma during clamping, and the effects of high blood flow on the venous system are among the main explanations for the frequency of venous stenosis (anastomotic or postanastomotic) after construction of prosthetic arteriovenous grafts. Creation of an AVALG requires clamping of the axillary vein downstream, and vascular clamps can promote stenosis of the venous segment of vascular hemodialysis accesses. However, brachial-axillary grafts, which also require axillary vein clamping, have a lower incidence of venous stenosis. Oguzkurt et al reported a potential correlation between central venous stenosis and high blood flow in vessels accessed for hemodialysis. One might assume that the proximal location of AVALG with potential consequent high flow rate, could explain the frequency of venous stenosis in our study. Although we cannot entirely discount this hypothesis, flow rate was between 0.85 liter/min. and 1.3 liter/min. in our patients, and thus, did not reach the mean 2.3 liter/min reported in Oguzkurt’s article. Likewise, no high blood flow-induced heart failure was diagnosed in our patients, but the duration of follow-up in our study may be insufficient to judge the potential cardiac repercussion of AVALG. Missed central venous lesion by preoperative Doppler ultrasound may also account for the frequency of venous stenosis in our study population. Indeed, phlebography or magnetic resonance angiography (MRA) is more reliable than Doppler ultrasound for the diagnosis of central venous lesions. In our policy we have used Doppler ultrasound as the initial exam and rarely performed phlebography. We were probably wrong and should adhere to the guidelines by using routine phlebography or routine MRA before all AVALG construction. In our opinion, that could only improve further the functional patency of AVALG and extend its indications to patients with false negative Doppler examination for central vein stenosis. Infection occurred in 11% of our patients, a rate only slightly higher than the 10% judged acceptable by the National Kidney Foundation (guideline 32). Nevertheless, these graft infections, mostly related to needle site puncture, were associated with two cases of AVALG failure and permanent loss. A strict protocol guaranteeing diversification of axillary loop puncture sites might reduce the incidence of infectious complications. The 15% mortality rate at 1 year in our patients (mean age 73 years) is consistent with the mortality rates usually reported for elderly patients on chronic hemodialysis who have an arteriovenous graft. Furthermore, no patient death was related to the presence or construction of an axillary loop.
To our knowledge, this is the first report on the use of AVALG for hemodialysis access. We have preferred the right axillary vessels rather than the left (24 vs 3) for creating AVALG since it is more likely for the left brachiocephalic vein to be compressed by the innominate artery and lead to stenosis downstream the left axillary vein under a relatively high flow rate regimen. Besides, the indications and the role of this technique for construction and maintenance of a patent vascular hemodialysis access have not yet been established. One of our patients, who presented arterial ulcers of the hand, underwent successful AVALG construction after ligation of a functional brachiocephalic fistula. Distal revascularization-interval ligation (DRIL), as recommended by Schanzer et al, gold standard in this indication, was not possible in this patient because of the severely septic lesions on his hand. Our approach was, nevertheless, justified by the study data published by Gradman and Pozrikidis, who demonstrated improved distal perfusion with axillary-axillary arteriovenous graft in vitro. As those authors stated previously, transposing the origin of a brachial-axillary access from a distal brachial artery to a more centrally site in the arterial circulation could also increases flow to both the access and the forearm as do the DRIL procedure, since flow in each configuration (DRIL and AVALG) divides in the axilla and each access consists of a descending and ascending limb.

Aside from this steal syndrome case, the main indications for AVALG construction in our chronic hemodialysis patients were exhaustion of conventional upper limb vascular access sites and inadequacy of upper limb veins for construction of an autologous arteriovenous fistula or a traditional upper extremity arteriovenous graft. Several innovative alternative techniques, often reflecting great creativity, have been proposed for those indications. Use of lower extremity vessels and exotic arteriovenous graft configurations (axillary-jugular, axillary-contralateral axillary, axillary-femoral, or even axillary-popliteal) have been reported, but their results remain uncertain. Burger et al reported acceptable primary and secondary patency rates (90% and 93% at 6 months, respectively) using axillary-axillary interarterial chest loop conduits. Huber et al described translocation of the superficial femoral vein to the upper extremity for creation of a brachial-axillary graft. Angle and Chandra performed two-stage construction of an arteriovenous brachial-brachial fistula as the initial surgical vascular access in some 20 patients who were starting hemodialysis without any superficial vein suitable for autogenous vascular access construction.

On the whole, we preferred AVALG rather than any arteriovenous access involving lower extremity vessels owing to the latter’s higher inherent risks of sepsis, ischemia, and amputation. Likewise, interarterial loops were not used because of their theoretical risks of ischemia and distal embolization. Zanow and Bungert reported this last complication in 5% and 3.2% of patients with an interarterial axillary-axillary loop for hemodialysis, respectively. To the best of our knowledge, the feasibility of arteriovenous brachial-brachial fistulas was not evaluated in chronic hemodialysis patients who had undergone one or more earlier attempts at surgical vascular access.

One potential limitation of axillary loops is the need for construction under general anesthesia in patients who are already fragile. One could consider a contraindication of general anesthesia as a theoretical contraindication for AVALG construction. Although various local-regional anesthesia techniques can be used for loop graft construction, they were not used for any of our patients. Absolute intraoperative patient immobility appears important during graft anastomosis to the axillary vessels. While the frequency of secondary procedures may appear elevated, such procedures are often needed to maintain the patency of prosthetic vascular accesses. Furthermore, most of these secondary procedures were performed under local anesthesia with very little additional morbidity.

The results and low postoperative morbidity of these 27 prosthetic arteriovenous axillary loops suggest that this technique may be performed simply. A patent AVALG permits satisfactory hemodialysis for ESRD patients after exhaustion of traditional possibilities for upper extremity vascular access. In case of AVALG failure, another hemodialysis access can be constructed using lower extremity vessels. Our findings also suggest that creation of an AVALG does not compromise alternate placement of an indwelling central venous catheter in the ipsilateral jugular vein.

CONCLUSION

This study demonstrated that construction of AVALG is a supplementary alternative for patients on chronic hemodialysis with inadequate upper extremity venous access options or vascular steal. Results suggest that AVALG construction may be preferable to lower extremity vascular access, in particular for patients without any history of subclavian vein catheterization or pacemaker placement. Additional prospective studies including greater numbers of patients may be warranted to confirm these observations.

AUTHOR CONTRIBUTIONS

Conception and design: EJ, RH, PB
Analysis and interpretation: EJ, RH
Data collection: EJ, RH, PH, PB, SD, MB
Writing the article: EJ, RH
Critical revision of the article: EJ, RH, PH, PB, SD, MB
Final approval of the article: EJ, RH, PH, PB, SD, MB
Statistical analysis: EJ
Obtained funding: Not applicable
Overall responsibility: EJ, RH

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Submitted Aug 2, 2007; accepted Sep 25, 2007.