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OUTCOMES OF ARTERIOARTERIAL PROSTHETIC LOOP GRAFT AS AN ALTERNATIVE HEMODIALYSIS ACCESS

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Keywords: *Arterioarterial, hemodialysis, Loop graft.*

Abstract

Objective: to describe the technique and study the safety and efficacy of arterioarterial prosthetic loop graft as a hemiodialysis access option in multi-access failure patients.

Methods: This is a retrospective single center study which was conducted at the vascular surgery department in KHMC. Data of patients who underwent arterioarterial loop graft in the period between January 2014 and January 2019 was collected and analyzed.

Results: 23 patients underwent the procedure. 18 patients underwent anterior chest wall axilloaxillary arterial loop graft while 5 patients underwent arterioarterial loop graft based of the superficial femoral artery (SFA).

The primary patency rates at 6, 12, and 18 months were 91.3%, 74%, and 61% respectively. The secondary patency rates at 6, 12, and 18 months were 95.6%, 82.6%, and 78.3% respectively. Three patients developed localized graft infection at the site of puncture. Two patients developed false aneurysms in the body of the graft. 0ne patient developed limb threatening ischemia secondary to graft thrombosis. There was no procedure related mortality.

Conclusions: Prosthetic arterioarterial loop graft is a safe and effective hemodialysis access option in carefully selected subsets of end stage renal disease patients.

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Introduction

Over the last few decades, the incidence of chronic kidney disease (CKD) and end-stage renal disease (ESRD) has increased steadily in Jordan and worldwide secondary to diabetic and hypertensive nephropathy. Data from the United States Renal Data System in the year 2015 revealed that 117162 new patients were started on hemodialysis therapy[1].Permanent hemodialysis access is vital for those patients to achieve acceptable lifestyle and long-term survival. Native (autologus) upper limb arteriovenous fistula is the gold standard access because it has the best patency rates and associated with much less complications when compared to prosthetic grafts and temporary catheters[2,3].Prosthetic arteriovenous grafts in both upper and lower extremities represent a valid option in patients with exhausted superficial veins[4-6].However;many patients have exhausted peripheral veins or occluded central veins which preclude creation of suitable arteriovenous access. Moreover, some patients have heart failure which could be exacerbated by creation of arteriovenous fistula. Arterioarterial prosthetic graft may represent a valid solution for those challenging groups of patients. The idea of using an artery or an arterioarterial graft as a permanent hemodialysis access is not a new one. In 1976, Butt and Kountz[8] described the use of a bovine carotid artery which was configured as a femoropopliteal Jump graft and was used as a hemodialysis access and it was associated with good patency and acceptable complicationrates. Zanow et al[9] published their experience in using 36 arterioarterial loop grafts as a hemodialysis access based off the axillary or femoral arteries. The secondary patency rates at 1 and 3 years were 96% and 87% respectively. The aim of our study is to review our results and to describe the technique of arterioarterial hemodialysis grafts in both upper and lower limbs.

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Methods and surgical technique

The vascular surgery unit at KHMC is the main referral unit for creation of hemodialysis access in Jordan. We have reviewed the operating room records, the vascular laboratory records, patients' case notes, and dialysis units' records at KHMC to collect pertinent data. All patients underwent detailed physical examination to look for signs of central venous occlusion and to assess the pulse status in the upper and lower limbs. Arterial and venous duplex scan was performed for all patients before labeling them as unsuitable for any form of arteriovenous fistula. Echocardiography and cardiologic assessment was done for patients with heart failure and ejection fraction below 30% was an indication for an AAPLG. Among patients who were considered unsuitable for upper or lower limb arteriovenous fistula or arteriovenous grafts, 23 patients were considered candidates for AAPLG and underwent the procedure during the period between January 2014 and January 2019. 18 patients underwent anterior chest wall axilloaxillary arterial loop graft while 5 patients underwent thigh arterioarterial loop graft based of the superficial femoral artery (SFA).

The indications for the AAPLG were as follow: 9 patients had exhausted superficial and deep veins in both upper and lower extremities, 11 patients had occluded central veins and failed trials of recanalisation, and 3 patients had heart failure which was refractory to medical treatment and creation of arteriovenous fistula would add more burden on the heart.

General anesthesia was used in 16 of the 18 patients who underwent anterior chest wall AAPLG while local anesthesia was used in 2 patients as they had hyperkalemia and were considered very high risk for general anesthesia. Spinal ansthesia was used in the 5 lower limb AAPLGs. Prophylactic dose of antibiotics (cephalosporin) was given to all patients 30 minutes before surgery. The axilloaxillary AAPLG was performed while the patient was in supine position. An infraclaviculr transverse incision (7-10 cm) long was used for exposure of the 2nd and 3rd parts of the axillary artery. After opening the skin and subcutaneous tissue; the pectoralis major muscle was split along its fibers and the pectoralis minor was divded as high as possible, all crossing veins were ligated to mobilize adequate length of the axillary artery. The graft which was used in our patients was the 7-mm Flixene (AtriumMedical,Hudson,NewHampshire,USA) . The graft was tunneled in the anterior chest wall in a loop configuration using two counter incisions. The graft was immersed in diluted rifampicin solution and the tunnel was irrigated with rifampicin solution.The axillary artery was transected, then the graft was anastomsed to the proximal followed by the distal transected artery in an end to end configuration as shown in figure 1. A negative pressure drain was inserted in all cases and wounds were closed in two layers.

The SFA- based grafts were performed under spinal anesthesia, patients were in supine position. The knee was flexed and the hip was in flexion and external rotation. The mid part of the SFA was exposed in the subsartorial plane. The same graft was used as in the anterior chest wall. The graft was tunneled in the anteriolateral aspect of the thigh in a loop configuration using two small counter incisions. Both ends of the graft were anastomosed to both ends of the SFA in an end to end technique as shown in figure 2. The technical success of the procedure was checked by palpation of distal pulses and using the hand held Doppler to assess the arterial signal at the wrist and ankle levels.

Lifelong aspirin and short course of oral antibiotics were prescribed for all Patients on discharge and given appointments in the clinic after one week. Patients were followed up in the clinic after two weeks, then every two months for a minimum of one year.
Patients were allowed to use the graft after 24 hours of surgery if necessary but were advised to postpone puncturing the graft for two weeks if possible.

Patients and nephrologists were given special instructions regarding the use of this type of grafts which included:

1- Avoidance of direct injection of medications in the graft because of the detrimental effects of intra-arterial injections.
2- Avoid high flow dialysis (> 400 mL /min) to prevent painful reperfusion.
3- Application of direct pressure over the puncture site for 20-25 minutes to avoid bleeding and false aneurysm formmation.
4- Insertion of the arterial and venous lines of the dialysis machine should be according to the diagram given to the patients upon discharge.

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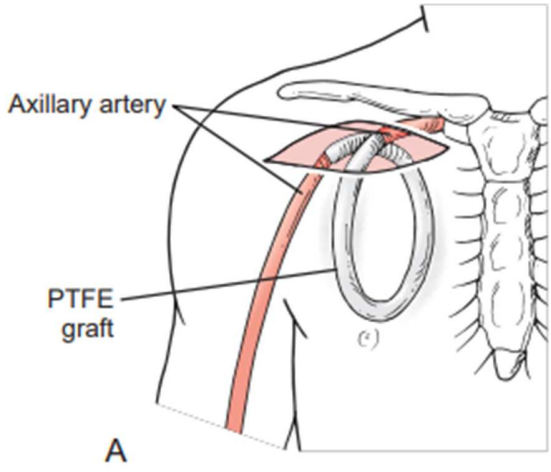

Figure 1: Chest wall Arterioarterial loop graft

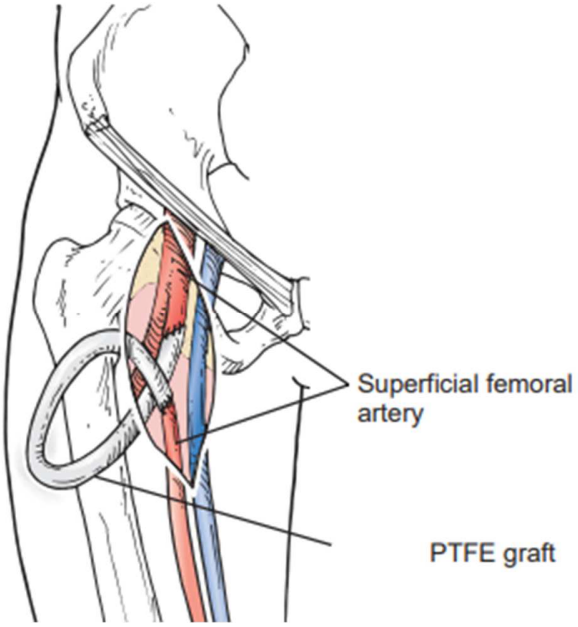

Figure 2: Thigh (SFA based)arterioarterial loop graft.

Results

In our study, 23 patients underwent AAPLG from January 2014 to January 2019 with a minimum of 18 months of follow-up. This cohort consisted of 13 males (56.5%) and 10 females (43.5%). The age ranged between 27-63 years with the median age of 47.3 years.

11 (47.8%) patients were diabetics, and 13 (56.5%) patients were hypertensive. Of our patients, 21 (91.3%) patients had a history of upper and lower extremities access surgery with an average of 4.6 procedures. Before undertaking the procedure, 14 patients were maintained on hemodialysis through a temporary femoral vein catheter (61%), 6 patients were maintained through a temporary jugular vein catheter (26%), and 3 patients were maintained through a malfunctioning AV graft (13%) .The demographic data are summarized in Table 1.

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Technical success was 100 % as all patients had good function immediately after surgery and at 24 hours after the procedure. All patients were scheduled for regular follow up in the vascular surgery clinic, the shortest follow up duration was 18 months and the longest follow up duration was 41 months with an average of 33.2 months.
Two patients developed hematomas in the chest wall wound one day post operatively, one of them was successfully managed conservatively, the other one needed wound exploration and hematoma evacuation with uneventful recovery. Four patients developed small hematomas at the site of cannulation due to early use of the graft; all were managed conservatively with complete resolution and preservation of graft function. Three patients had localized graft infection at the site of repeated cannulation with damaged skin. Two of them were in chest wall grafts while the third one was in a thigh graft. All of them were managed by excision of the involved segment and replacement by graft interposition in a new subcutaneous tunnel, graft function was preserved in all of them and the patients resumed dialysis from the grafts. On follow up, wounds healed with no evidence of recurrence of graft infection.

Two patients developed false aneurysms in the body of the grafts, one was in a chest wall graft and the other one was in a thigh graft, both of them were successfully treated by excision of the false aneurysm and insertion of graft interposition. One patient with SFA based thigh graft presented with signs of acute limb ischemia and underwent immediate graft thrombectomy and the limb was preserved. Other patients who presented with graft thrombosis had either no ischemic symptoms or mild ischemic symptoms which were well tolerated by the patients and resolved after graft thrombectomy. In this study, the AAPLG did not worsen the congestive heart failure in patients with impaired cardiac function during the follow-up period.Table 2 summarizes the complications.

Using Kaplan Meier analysis, the primary patency rates at 6, 12, and 18 months were 91.3%, 74%, and 61% respectively. The secondary patency rates at 6, 12, and 18 months were 95.6%, 82.6%, and 78.3% respectively. The average primary and secondary patency durations were 15.9 months and 16.7 months, respectively. Figure 3&4 illustrates these results.

Clinical variables associated with outcomes were analyzed using Pearson Correlation with a 95% confidence interval. The results indicated that older age (p= 0.015) and diabetes mellitus (P= 0.037), were significantly associated with a decreased primary patency.

A Log Rank (Mantel-Cox) test was performed to determine if there were differences in the survival distribution for the different types of procedures: anterior chest wall axilloaxillary arterial loop graft and arterioarterial loop graft based of the superficial femoral artery (SFA). The survival distributions for both procedures were statistically significantly different, $\chi 2\ (2) = 7.968$, $p < .05$.As shown in figure 5, The survival curves are somehow similarly shaped. However, the cumulative survival proportion appears higher in the first procedure compared to the second procedure. It would appear that the anterior chest wall axilloaxillary arterial loop graft procedure may prolong the survival compared to the other procedure, p value < .05 (p= .003).

Table 1: Patients' Demographics, Medical History.

Characteristics	***Number (%)***
Sex: Male Female	 13/23(56.5%) 10/23(43.5%)
Age	27-63 (mean 47.3) years
Diabetes	11/23(47.8%)
Hypertension	13/23(56.5%)
Previous arteriovenous fistula or graft	21/23(91.3%) average 4.6 procedures.
Anesthesia: General Spinal	 16/23(69.6%) 5/23(21.7%)

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Local	2/23(8.7%)
Clinical indications Exhausted superficial and deep veins Occluded central veins Heart failure	 9/23 11/23 3/23

Table 2: Complications Related to the AAPLG

Complication	Number (%)
Hematoma *Wound hematoma* *Tunnel Hematoma*	 2/23(8.7%) 4/23(17.4%)
Graft Infection *Chest wall graft* *Thigh graft*	 2/23(8.7%) 1/23(4.3%)
False aneurysm *Chest wall graft* *Thigh graft*	 1/23(4.3%) 1/23(4.3%)
Limb Threatening Ischemia *Thigh graft*	 1/23(4%)

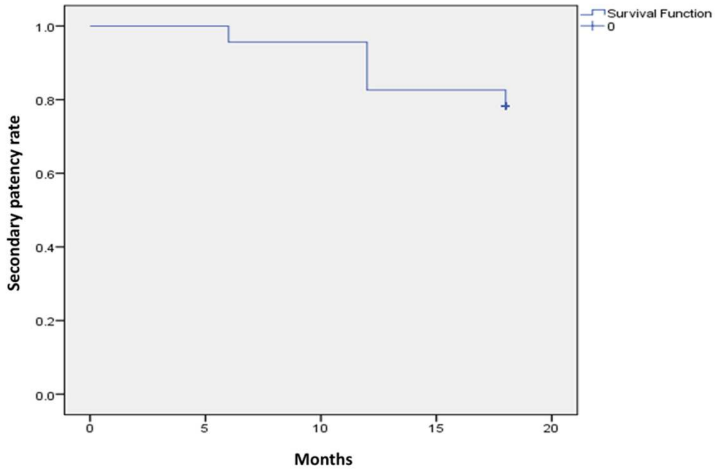

Figure 3: Kaplan Meier estimate curve for primary patency rates.

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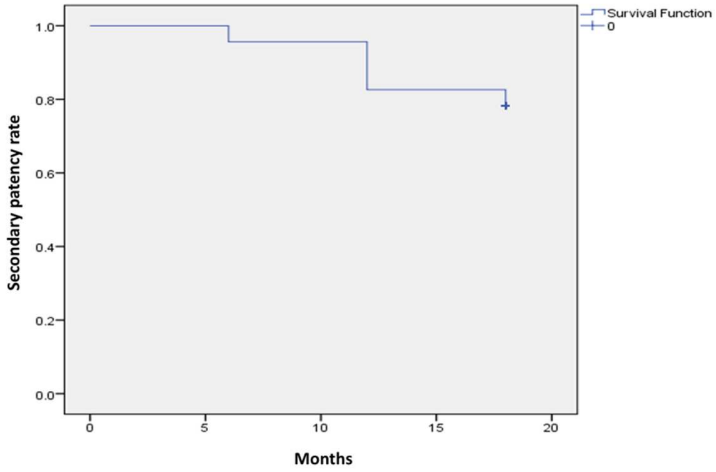

Figure 4: Kaplan Meier estimate curve for secondary patency rates.

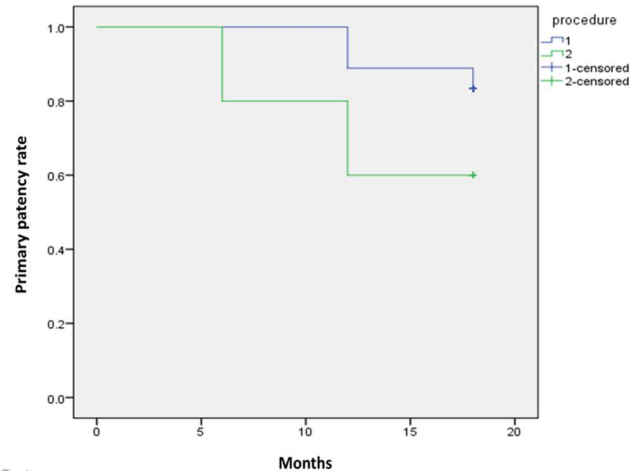

Figure 5: Survival distributions between procedures. Procedure =1 is anterior chest wall axilloaxillary arterial loop graft , Procedure =2 is arterioarterial loop graft based of the superficial femoral artery (SFA).

Discussion

Creation and maintenance of a reliable hemodialysis access that has a flow rate adequate for effective dialysis, and has high patency and low complication rates is vital for hemodialysis dependent patients to ensure good quality of life and long term survival[10]. Many authors reported their experience in using an artery or an arterial bypass graft as a hemodialysis access in patients with no arteriovenous access option[8,11,12,13]. Arterioarterial grafts as a hemodilysis access has many advantages and disadvantages[9, 14]. Advantages of an arterioarterial graft include:

1- A patent superficial or deep vein is not needed.
2- No risk of arterial steal syndrome as distal perfusion is not affected.
3- No risk of exacerbating heart failure because cardiac load is not increased.

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Problems associated with arterioarterial grafts include:

1- Thrombosis of the graft my result in distal limb ischemia especially in grafts based of the femoral artery.
2- Major arterial reconstruction may be needed if graft infection develops.
3- Painful reperfusion and risk of distal embolisation.

The Idea of central venous recanalisation with or without stenting or adopting newer techniques like HeRO device as an option before using arterioarterial grafts are associated with high costs in relation to its durability and limited availability[15], so in our vascular surgery department at KHMC, we used the AAPLG as a bailout procedure to create a reliable hemodialysis access in those patients who have no option to create an arteriovnous fistula or graft. We performed 23 AAPLGs with 100% immediate techniqal success rate. All patients had adequate dialysis from the grafts. The encountered complications were within accepted rates of complications that are usually seen in prosthetic vascular access grafts. The primary patency rates at 6, 12, and 18 months were 91.3% , 74%, and 61% respectively. The secondary patency rates at 6, 12, and 18 months were 95.6%, 82.6%, and 78.3% respectively after successful thrombectomy. Our results were comparable to the patency rates which were reported by Lei et al[16] who used the common femoral and profunda femoris arteries to create thigh arterioarterial grafts, the 6 months primary and secondary patency rates were 94.5 and 88.8%, respectively; while the 3 years primary and secondary rates were 61% and 72%, respectively. Ali et al reported their experience in 89 brachiobrachial arterioarterial hemodialysis grafts. The reported primary, assisted primary, and secondary patency rates at 6 months were 87.5%, 90.9%, and 97.7% respectively; and at 1 year were 71.5%, 79.5%, and 93.2% ,and at 2 years were 62%, 71.2%, and 89.6%, respectively. Grima et al[18] performed a systematic review of 8 studies which described different sites and configurations of arterioarterial grafts, the primary patency rates at 6 months ranged from 67% to 94.5% and at 3 years ranged from 38.8% to 61% ,and secondary patency rates ranged from 83% to 93% at 6 months and 67.6% to 87% at 3 years.
We observed that thrombosis of AAPLG was well tolerated in all cases except one patient with SFA based thigh graft who presented with signs of acute limb ischemia and underwent immediate graft thrombectomy which was successful with no documented cases of limb loss or critical ischemia in both chest wall and thigh grafts. Early cannulation of the graft was associated with perigraft hematoma in 4 patients which makes further cannulation in the subsequent sessions more risky, so we advise to postpone using the arterioarterial grafts for 1-2 weeks unless the patient has no other functioning angioaccess.

This study has some limitations as it is a retrospective study , it is a single center study , and included small number of patients.

Conclusion

AAPLG should be considered in hemodialysis dependent patients who have no other option for conventional permanent HD access. It is associated with good patency and acceptable complication rate. Cooperation with nephrologist and dialysis staff is mandatory because of unique features of this type of HD access.

Acknowledgements

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