Early Results of Arterioarterial Prosthetic Loop As a Bail Out Procedure in End Stage Renal Disease Patients With Multi-Access Failure

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ABSTRACT

Background: *Arteriovenous fistula (AVF) is the standard access for hemodialysis in end-stage renal disease (ESRD) patients on maintenance hemodialysis. Because of the higher rate of morbidity and mortality associated with central venous catheter (CVC), it should be used after exhaustion of all AVF options. Sometimes, insertion of CVC is very difficult or impossible even with radiological guidance due to central venous obstruction. Therefore, a category of patients with multi-access failure and central venous obstruction requires a reliable alternative access. Since arterio-arterial prosthetic loop (AAPL) was introduced as an access for hemodialysis with encouraging results, in the present study we studied the use of axillary-axillary AAPL for patients with multi-access failure and unsuitable for conventional vascular access.* ***Aim of the work:*** *Evaluation of the early results of axillary arterio-arterial synthetic loop as a vascular access for hemodialysis in ESRD patients with multi-access failure.* **Patients and methods:** *Twenty ESRD adult patients on maintenance hemodialysis with multi-access failure and unsuitable for conventional vascular access underwent Axillary arterio-arterial prosthetic loop procedure for hemodialysis. All patients were assessed preoperatively by duplex ultrasonography for the targeted upper limb. Polytetrafluroethylene (PTFE) graft was interpositioned in the end to end manner to the ends of the axillary artery after exposure of the artery through infraclavicular incision and creation of a subcutaneously looped tunnel on the chest wall. All patients received acetylsalisyslic acid indefinitely after the operation and puncture of the graft was allowed after 2 weeks. All patients had regular follow up visits for 6 months to assess the AAPL as regards: wound care, records from dialysis unit and exclude complications.* ***Results:*** *The indications for creation of AAPL included multi-access failure with no possibility to create native AVF or AVG in 17 patients (85%), while steal syndrome was the indication in 2 patients (10%) and heart failure in 1 patient (5%). The mean operative time was 120 minutes (ranging from 90 to 140 minutes). The median length of hospital stay after the procedure was 4 days (ranging from 2 to 5 days) and the perioperative mortality rate at 30 days was 5 %. The median access flow at rest was 200 ml/min (150 – 300 ml/min) at 1 month postoperatively, with no significant difference at 3 and 6 months. Primary and secondary patency rates at 6 months were 80% and 90% respectively. Access thrombosis occurred in 3 patients with mild hand ischemia and the graft was salvaged 2 patients, while in the third patient the graft was severely lacerated and was ligated. Severe infection was encountered in one patient with secondary hemorrhage which necessitated graft excision and ligation of the axillary artery with compensated upper limb.* **Conclusion:** *Axillary arterio-arterial prosthetic loop can be considered as an alternative procedure for hemodialysis in ESRD patients with multi-access failure and occlusion of central veins.*

Key words: *vascular access – arterioarterial prosthetic loop – hemodialysis.*

INTRODUCTION

Functioning vascular access (VA) is essential for an efficient hemodialysis (HD). AVF is the standard access for HD in ESRD patients on maintenance HD. [(1)] The introduction of prosthetic arteriovenous graft (AVG) and CVC has given the chance to choose the most suitable VA for HD patient. Because of the higher rate of morbidity (thrombosis, sepsis and central venous obstruction) and mortality associated with central CVC and AVG, they should be used after exhaustion of all AVF options. [(2)] Improvement in HD and better management of comorbidities resulted in higher life expectancy for dialysis patients. [(3)] According to guidelines of National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF- K/DOQI) [(4)], the preferred site for AVF is the forearm (radiocephalic) followed by the elbow (brachiocephalic) and lastly the arm (brachiobasilic AVF or brachial venae comitants AVF with superficialization). Well-functioning access should have flow ≥ 600 ml/min, vein diameter ≥ 6 mm and doesn't exceed 6 mm in depth.

Arteriovenous graft (AVG) is a graft interpositioned between an artery and a vein and it is the second step after exhaustion of native veins options. [(5)] Prosthetic AVGs are either autologous, biological or synthetic. AVG insertion in the upper extremity is preferred than the lower extremity, because of the lower risk of infection and sepsis. After exhaustion of upper limb sites, the thigh is the next site. AVG can be used in the straight, C- shaped or loop configuration. [(6- 8)]

Central Venous Catheters (CVC) is an option for urgent HD required at the time of dialysis initiation or permanent access dysfunction. [(9)] Preferable sites for CVC insertion are internal jugular vein (IJV), common femoral vein (CFV) and lastly subclavian vein (SCV).[(10)] Complications of CVCs include: complications associated with insertion as vascular injuries (arterial puncture, pseudoaneurysm) hematoma, air embolism, pneumothorax and malposition, [(11, 12)] indwelling complications (infection, thrombosis, catheter kinking and fracture with possible embolization. [(13)] Sometimes, insertion of CVC is very difficult or impossible even with radiological or ultrasonographic guidance due to central venous obstruction. [(14)] Therefore, a category of patients with multi-access failure and central venous obstruction requires a reliable alternative access.

Butt and Kountz [(15)] reported using a bovine carotid artery in creation of femeropopliteal interposition graft as vascular access with satisfactory result. In 2005, Bunger et al [(16)] performed axillary-axillary inter-arterial chest loop graft as an access for hemodialysis in 20 patients with good patency rate. Zanow et al [(17)] reported using a synthetic arterio-arterial (AA) loop in proximal axillary or femoral artery as a vascular access for hemodialysis with excellent results. Since the results of arterio-arterial prosthetic loop (AAPL) were encouraging, in the present study we used axillary-axillary AAPL for patients with multi-access failure and unsuitable for conventional vascular access.

AIM OF THE WORK

The aim of the work was to evaluate the early results of axillary arterio-arterial synthetic loop as a vascular access for hemodialysis in ESRD patients with multi-access failure.

PATIENTS AND METHODS

This study was done at Alexandria Main University Hospital on twenty ESRD adult patients on maintenance hemodialysis with multi-access failure and unsuitable for conventional vascular access. Duplex ultrasonography for the targeted upper limb was performed for all patients preoperatively: *Arterial duplex* to rule out arterial occlusions and *venous duplex* to exclude the presence of suitable veins for AVF.

- **Surgical procedure**

After Exposure of the axillary artery through infraclavicular incision and separation of cords of the brachial plexus (figure 1), a subcutaneously looped tunnel was created on the chest wall, then division of the axillary artery (figure 2) and polytetrafluroethylene (PTFE) graft was interpositioned in the end to end manner to the ends of the axillary artery after putting the graft in the subcutaneous tunnel (figure 3). The diameter of the graft was chosen according to the diameter of the axillary artery during surgery (6 mm or 8 mm). Intravenous unfractionated heparin 5000 i.u. was given before clamping of the axillary artery after securing hemostasis in the subcutaneous tunnel. A drain was left for few days. Patients received low molecular weight heparin (clexane) 20 mg/24 hours for 1 week and acetylsalisyslic acid (ASA) indefinitely. Puncture of the graft was allowed after 2 weeks to assume maturation of the incorporating tissue.

Figure (1): exposure of the axillary artery through infraclavicular incision

Figure (2): Creation of subcutaneous tunnel on the chest wall, then division of the axillary artery

Figure (3): Polytetrafluroethylene (PTFE) graft was interpositioned in the end to end manner to the ends of the axillary artery after putting the graft in the subcutaneous tunnel

Figure (4): the layout of the graft in the tunnel

- **Follow up**

All patients had regular follow up visits for 6 months to assess the AAPL as regard: wound care, records from dialysis unit (pressure and flow rate) and exclude complications (infection, pseudoaneurysm and others)

RESULTS

20 patients underwent axillary arterio-arterial prosthetic loop (AAPL) as a hemodialysis access. 13 of them were males and 7 were females with mean age of 50.2 years. All cases were done using PTFE graft under general anesthesia. Risk factors are given in table 1.

Table (1): Risk factors in the study population

Risk factor	**N (%)**
Diabetes mellitus	7 (35%)
Hypertension	10 (50%)
Coronary artery disease	8 (40%)
Congestive heart failure	1 (5%)
Cerebrovascular stroke	5 (25%)
Liver disease	7 (35%)

75 % of patients had history of 3 or more native AVF and 40 % had one or more AV graft as a previous permanent access.

Table (2): Distribution of studied cases according to previous access procedures.

Type of access	**Number of trials**	**N (%)**
Native AVF	2	4 (20%)
	3	12 (60%)
	4	3 (15%)
AV grafts	1	6 (30%)
	2	2 (10%)

The indications for creation of AAPL included multi-access failure with no possibility to create native AVF (either at the wrist or the elbow or an upper limb AV graft in 17 patients (85%), while steal syndrome was the indication in 2 patients (10%) and heart failure in 1 patient (5%).

The mean operative time was 120 minutes (ranging from 90 to 140 minutes). The median length of hospital stay after the procedure was 4 days (ranging from 2 to 5 days). First cannulation of the access was performed after a median of 3 weeks (ranging from 2.1 to 4.2 weeks). The perioperative mortality rate at 30 days was 5 % (1 patient died from extensive myocardial infarction at the tenth postoperative day). In 13 patients the AAPL was performed on the left side, while in 7 patients it was performed on the right side. We tried to use 8 mm PTFE graft in most of the cases (14 patients), while in 6 patients we used 6 mm graft as the axillary artery diameter was relatively small. The characteristics of the procedure are listed in table (3). Postoperatively all patients received mono-antiplatlet therapy (ASA), except one patient who was already on vitamin K antagonist for cardiac reasons.

Table (3): Characteristics of the procedure (n=20).

Characteristics of the procedure	N (%)
Side of the procedure	
Left	13 (65%)
Right	7 (35%)
Diameter of the graft	
8 mm	14 (70%)
6 mm	6 (30%)
Operative time (minutes)	
Min. – Max.	90.0 – 140.0
Median	120.0

Postoperative complications, management and outcome (table 4):

The most commonly encountered complication was upper limb edema, which was managed conservatively and resolved after few weeks. Access thrombosis occurred in 3 patients with mild hand ischemia (one patient 25 days postoperatively another one after 2 months and the third patient had thrombosis after 4 months from the procedure), thrombectomy was done with disappearance of hand ischemia and salvage of the graft in 2 patients, while in the third patient the graft was severely lacerated with excision of a segment and graft ligation. Severe infection was encountered in one patient with secondary hemorrhage which necessitated graft excision and ligation of the axillary artery with compensated upper limb. One patient developed small lymphocele postoperatively at the infraclavicular incision, it was excised with no affection of the graft. Table 4 summarizes the complications found in the study group.

Table (4): Postoperative complications, management and outcome.

Complication	No.	%	Management	Outcome
Upper limb edema	5	25	Conservative	Resolved
Graft thrombosis	3	15	Thrombectomy	Salvage of graft in 2 patients Graft ligation in 1 patient
Graft infection	1	5	Excision of the graft and ligation of the axillary artery	Compensated limb
Lymphocele	1	5	Excision	No affection of the graft

The median access flow at rest was 200 ml/min (150–300 ml/min) at 1 month postoperatively, with no significant difference at 3 and 6 months. Primary and secondary patency rates at 6 months were 80% and 90% respectively. No significant change in the peak systolic velocity values before the operation and during follow up. Figure 5 shows two of the patients after several months of dialysis from the graft.

In 2 patients, interruption of blood supply to upper limb occurred (1 patient had graft excision and ligation of the axillary artery due to infection and in the other patient, graft thrombectomy failed and it was found lacerated and excised). Monophasic flow was found in the upper limb arterial tree with lower velocities compared to preoperative measurements. Figure 6 shows one of the patients with partial graft excision due to infection and foreign body granuloma at the remaining segments which was excised later (note the dilated chest wall collaterals secondary to central venous occlusion).


a b

Figure (5): Two patients with functioning AAPL. Image (a) after 3 months from operation, image (b) after 5 months (note the engorged neck veins secondary to central venous occlusion).

Figure (6): one of the patients with partial graft excision, due to infection showing foreign body granuloma at the remaining segments.

DISCUSSION

According to the K/DOQI guidelines, the use of native AVF as the primary vascular access is recommended before AVG implantation. [(3)] Each access has a limited lifetime due to intimal hyperplasia at the venous anastomosis and central venous stenosis or occlusion as a result of CVCs. With the increase in the population requiring hemodialysis, it is not uncommon to encounter patients with exhausted options for vascular access. [(18)]

The use of an artery as a permanent vascular access for HD is not a new procedure. Brittinger et al [(19)] used superficialized Superficial Femoral Artery for HD. Butt and Kountz[(15)] used bovine carotid artery interpositioned in the femeropopliteal area for HD with satisfactory results. The advantages of AAPL in comparison to native AVF and AVG are: firstly, vein is not essential. Secondly, distal perfusion is not decreased and lastly, no volume overload on the heart [(17)]. In the present study, 20 AAPL procedures were performed in 20 patients using PTFE graft in all patients. On the other hand, autologous vein graft was used in 2 patients (10% of cases) in the study done by Bunger et al. [(16)]

The main indication for AAPL was exhausted access options (85% of cases), steal syndrome (10% of cases); shunt ligation was done after failure of surgical procedures to preserve the fistula with creation of AAPL access later on. In one patient (5%), heart failure with fear of more cardiac deterioration was the indication of AAPL. These were more or less the same indications in other studies like Bunger et al [(16)] and Zanow et al. [(17)]

Zanow et al performed 36 AAPLs as a vascular access for 34 patients (31 axillary and 5 femoral). Lei et al [(20)] reported 18 AAPL procedures for 18 patients between the femoral artery and profunda femoris artery. Thigh AV access may be suitable, but it is associated with high infection rate ranging from 11% to 41%[(21, 22)]. This high rate of infection together with higher incidence of atherosclerosis in lower limbs compared to upper limbs were the reasons for us to choose axillary arterio-arterial loop access. [(23)]

The perioperative mortality rate was 5% and this is comparable to other studies like Bunger et al[(16)] and Zanow et al[(17)].

The initial procedures as well as graft excision were done under general anesthesia, while thrombectomy (3 procedures) were done under local anesthesia. Graft thrombectomy was done with exposure of the graft at the summit of the loop, proximal and distal thrombectomy using fogarty catheter. No distal embolization reported and none of the patients needed balloon angioplasty or stenting. Other authors like Bunger et al [(16)] reported the need for stenting after thrombectomy, due to the presence of neointimal hyperplasia in 2 patients. The explanation for this may be the short follow up period in the present study compared to other studies. Also, those patients who needed stenting in Bunger et al study reported more durable outcome compared to the results of angioplasty and stenting in patients with AV access, [(24, 25)] but this has to be proven in longer follow up studies with more patients.

Bunger et al [16] reported high revision rate up to 30% in initial cases, due to bleeding complications from pectoralis muscle. Later on, the revision rate decreased; because they paid special attention to meticulous hemostasis on exposure of the axillary artery. In the present study, exposure of the axillary artery from infraclavicular incision and creation of the tunnel needed meticulous dissection and proper hemostasis in the operative field, because of the presence of extensive venous collaterals on the chest wall secondary to central venous occlusion in most of the patients.

Postoperative single antiplatelet (ASA) was given to 19 patients (95%), while one patient only received vitamin K antagonist (warfarin) for cardiac reasons. Although, Bunger et el reported the use postoperative clopidogrel for all of the studied cases, for fear of increased risk of gastrointestinal (GI) bleeding associated with use of ASA in uremic patients, [26] none of the patients in the present study developed GI bleeding during the follow up period. This may be due to the routine use of proton pump inhibitors in most of the patients. Dual antiplatelet therapy should be avoided in ESRD patients, as it has increased risk of bleeding. [27]

In the present study, the median access flow at rest was 200 ml/min (150 – 300 ml/min) at 1 month postoperatively, with no significant difference at 3 and 6 months with efficient dialysis. Zanow et al [17] reported postoperative flow rate of 272 ± 61 ml/min for axillary AAPL and 416 ± 40 ml/min for femoral AAPL. Bunger et al [16] reported median access flow of 165 ml/min.

Using AAPL for HD needs certain precautions; diagram should be drawn for dialysis team, showing configuration of the graft and direction of the flow, for better graft puncture and efficient HD. Also, the intraluminal pressure in AAPL is higher than the pressure of the native AVF or AVG, so it needs careful puncture and prolonged compression at the puncture site after withdrawal of the needle to guard against pseudoaneurysm formation. [28] Dialysis team should be instructed not to give any medication in the access to avoid pain and possible manifestations of intra-arterial drug injection. One of the patients in the study group experienced severe pain after receiving antibiotic injection in the access during dialysis session, but fortunately there was no effect on thee distal circulation.

CONCLUSION

Axillary arterio-arterial prosthetic loop can be considered as an alternative procedure for hemodialysis in ESRD patients with multi-access failure and occlusion of central veins with promising early results and accepted perioperative morbidity and mortality, however further studies are necessary to demonstrate the long term patency rate and the late complications

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