The Outcome of Simultaneous Brachial Artery Reconstruction and New Arteriovenous Fistula Construction using Great Saphenous Vein Conduit in Abandoned Limbs Due to Previously Ligated Brachial Artery

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ABSTRACT

Background: *Well functioning vascular access is considered the cornerstone for efficient regular hemodialysis and good overall quality of life. The ever-increasing life expectancy of patients on hemodialysis is accompanied with increasing subsets of those with exhausted upper extremity accesses.* ***Aim of the study:*** *To evaluate the feasibility, safety, limitations and outcome of using a great saphenous vein graft (GSV) to reconstruct a previously ligated brachial artery, and simultaneously construct a new autogenous arteriovenous fistula (AVF).* ***Patients and methods:*** *This study included 18 end stage renal disease patients on regular hemodialysis who had previous brachial artery ligation due to complicated AVFs or AV grafts (AVG); and already had exhausted other safe access sites. A GSV graft was used as a conduit to reconstruct the brachial artery and construct a new AVF. Technical success, operative time, complication and patency rate were evaluated.* ***Results:*** *Although some difficulties where encountered in 3 patients, yet, technical success were the end result in all patients with their fistulae got matured. The operative time was 70-120 minutes (mean 90 minutes). The mean follow up was 24 months. Neither early nor late thrombosis was encountered in brachial artery reconstruction, whereas, two cases of thrombosis were met in fistula construction after 3 and 11 months. One case developed grade I vascular steal. Late access stenosis occurred in 5 cases. At 6, 12, 18, 24 months, the primary patency rates of the constructed fistulae were 83.3%, 77.7%, 72.2%, 61.1% while the secondary patency rates were 88.8%, 83.3%, 77.7%, 66.6%.* ***Conclusion: S****imultaneous brachial artery reconstruction and new fistula construction using great saphenous vein conduit in limbs with previously ligated brachial artery proved to be feasible and safe with reasonable outcome. It offers a valid autologous alternative in some patients with limited vascular access options as a bail-out procedure before embarking to more sophisticated options.*

Key words: *Brachial artery ligation, ruptured arteriovenous fistula, saphenous vein graft.*

INTRODUCTION

Vascular access (VA) is considered the "lifeline" for chronic kidney disease (CKD) patients on regular hemodialysis.[1,2] Owing to their potential better patency and lower complication rates, autogenous AVFs are superior to artificial grafts and dialysis catheters. Many decades of clinical experience have repeatedly proved the tremendous clinical and economic superiority of native AVFs owing to significantly better primary patency rate after maturation (85% versus 50% at 1 year and 75% versus 25% at 2 years) and a much lower infection rate when compared with AVGs. [3,4]

With the ever-increasing longevity of the population and physicians' improving ability to treat CKD, the need for creation of VA in patients with exhausted access sites continues to be a challenging issue.[5] It is not uncommon to encounter patients having unilateral or even bilateral previously ligated brachial artery in the context of treatment of infected complicated AVF or AVG at the elbow level. The aim of this study is to assess the outcome of using a GSV graft to reconstruct the brachial artery in such patients and in the mean time to construct a new autogenous AVF regarding technical & clinical success, limitations, complications and patency rate of both the reconstructed artery and the constructed fistula.

PATIENTS AND METHODS

This study was conducted mainly in Kasr El Aini - Cairo University hospitals, from January 2012 to June 2013. Eighteen consecutive patients with CKD on regular hemodialysis were included

in the study. Demographic and clinical data including age, gender, cause of renal failure, and the presence of cardiovascular co-morbidities were obtained. Past and current access histories were recorded. Color duplex ultrasound (CDU) was used for both selection of the candidate patients for the study and also for their detailed assessment. CDU aimed at evaluation of patency and caliber of the venous tree of the target limb, mapping of both GSVs to detect those of good caliber ≥ 3 mm in diameter and assessment of the arterial tree above and below the ligation site. Further assessment of the arterial tree by CT angiography (CTA) was also done in some cases.

Fifteen patients had unilateral and 3 had bilateral previously ligated lower brachial artery as a life saving management of ruptured or infected AV fistula or AVG at the elbow level at least 3 months prior to the reconstructive procedure. Patients with unilateral brachial artery ligation had already exhausted their native access sites of the other upper limb and have been actively dialyzing through central venous catheters. CDU showed adequate patent variable lengths of proximal segments of either the cephalic vein (n=12) or superficialized basilica vein (n=4). There were no available patent superficial arm vein segment in the remaining 2 patients, thus, they were scheduled for brachio-axillary fistula construction using GSV long graft.

Exclusion criteria included patients with unresolved infection at the target limb, CTA evidence of poor run off distal to the ligated brachial artery segment, those having complex ipsilateral central venous occlusion not amenable to PTA & stenting and those with GSV diameter <3 mm.

The study was approved by the ethical committee, and informed written consents were obtained from the included patients who were scheduled for a single-stage procedure.

Operative technique:

The procedure was done as a day case procedure under local anaesthesia (diluted lidocaine hydrochloride 1% to augment the volume) with mild intravenous sedation (mediazolam 0.03 – 0.1 mg/kg). The entire upper limb up to the axilla together with the intended side for GSV harvesting were prepared and draped.

Arterial exposure was carried out to reach virgin segments of the brachial artery as near as possible to the site of ligation proximally and distally. This was carried out either by a single or two separate incisions. Another incision was also made along a previously marked patent superficial arm vein segment. A reasonable segment of the vein was dissected, controlled and tested for patency. At this point, the landing sites for the GSV graft are ready for the rest of the procedure **(Figure 1)**.

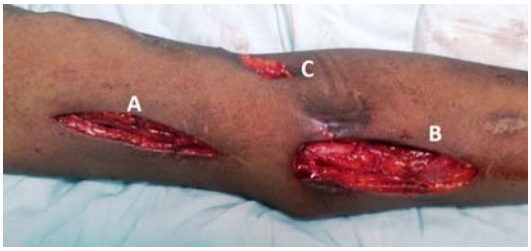

Fig. 1: The left upper limb of a CKD patient. A. Proximal incision to control the brachial artery above the ligated segment. B. Distal incision to control the brachial artery above its bifurcation. C. Exposure of a patent segment of the cephalic vein. Note the evidence of multiple scars of previous access trials.

A segment of the GSV well beyond the needed length to bridge the brachial artery gap and to construct the AVF was harvested. The brachial artery was then reconstructed first using a reversed interposition segment **(Figures 2 and 3)**. Anastomosis was performed in an end to end fashion using polypropylene 6/0 in most cases. The distal stump of brachial artery was too small in 5 cases, thus the vein graft was anastomosed to a longitudinal arteriotomy above the bifurcation of the brachial artery in an end to side fashion.

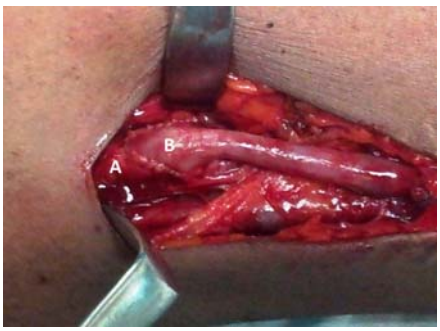

Fig. 2: End to end anastomosis of the proximal end of the brachial artery (A) to the proximal end of GSV graft (B).

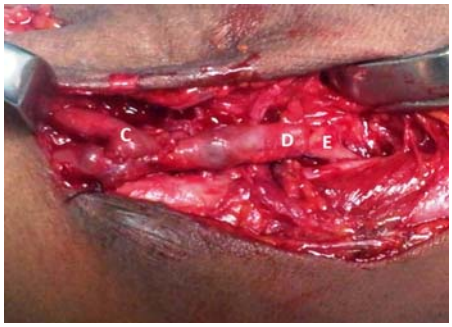

Fig. 3: Completion of brachial artery reconstruction by reversed GSV interposition graft. End to end anastomosis of GSV graft (D) to the brachial artery stump just above its bifurcation (E). AVF construction in an end to side fashion to the reconstructed brachial artery is seen(C).

Construction of the new AVF was then carried out using the remaining part of the harvested GSV without being reversed. End to end upper veino-venous anastomosis was first done using polypropylene 6/0. The GSV graft was then tunneled subcutaneously to meet the side of brachial artery interposition graft in an end to side fashion **(Figure 4)**.

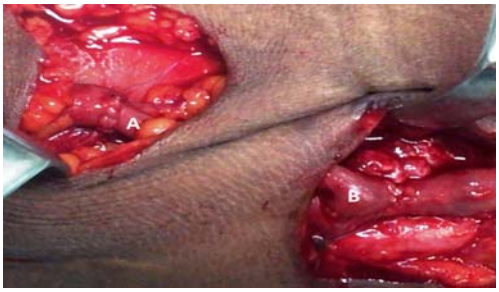

Fig. 4: Completion of AVF construction. End to end anastomosis of GSV segment to the left cephalic vein at (A). End to side anastomosis of GSV segment to the reconstructed brachial artery vein graft at (B).

Distal pulsations and quality of thrill were checked after completion of the anastomoses. Hemostasis was ensured and wounds were closed without drains. Patients were closely monitored for possible postoperative events with special concern to hand ischemia and evidence of fistula function. Low molecular weight heparin (Enoxaparin sodium 40 mg/12 hours subcutaneously) was given for 1 week. After discharge, patients were followed through outpatient clinic weekly visit until the access was successfully used for dialysis and 3 monthly thereafter. Fistula patency was defined as follows: Primary patency is the duration of fistula patency without revision. Secondary patency is the duration of patency after successful later revision. The patency rate at certain time is the percentage of AVFs still functioning at that time. [6]

RESULTS

A total of 18 patients (11 males and 7 females) were included in the study. Their mean age was 48±10 years (range, 32-64 years). Co-morbidities included hypertension (61%), diabetes (44.4%) and coronary artery disease (27.7%); and there was no significant impact of them on the outcome. ***Table 1 shows patients demographics and comorbidities***. The underlying causes of their renal impairment were hypertension (n=7), chronic glomerulonephritis (n=5), diabetes (n=4), chronic pyelonephritis (n=1) and obstructive uropathy (n=1). The study patients were on dialysis for 12±5 years (range, 6-21 years) and had undergone 6±2 previous access procedures (range, 4-8). Thirteen patients were actively dialyzing at the time of presentation through tunneled hemodialysis catheters, whereas temporary catheters were used in 5 patients.

Table 1: Patients´ demographics and comorbiditis

Patients total number	***18***
Mean age (Year)	48 ± 10
Range (Year)	32-64
Gender	11 Male (61.1%) 7 Female (38.8%)
Hypertension	11 (61.1%)
Diabetes	8 (44.4%)
Coronary artery disease	5 (27.7%)

The operative time was 70- 120 minutes (mean 90 minutes). The mean GSV diameter was 4.7±0.5mm (range 4-5.6mm) in the thigh segment. Technical success was achieved in all patients. One patient developed grade I vascular steal immediately post-operative and was managed conservatively. Minimal bleeding was observed in 1 patient who was managed by mild compression and holding anticoagulants. Superficial wound infection occurred in 2 patients

and required oral antibiotics for 2 weeks after the procedure.

The mean follow up time was 24 months. All AVFs got matured, and started to be used at an average of 6 weeks (range, 3-8 weeks) after surgery. Neither early nor late thrombosis was encountered in brachial artery reconstruction, whereas two cases of thrombosis were met in fistula construction after 3 and 11 months. Delay in cannulation was mainly due to prolonged arm swelling (n=1) and superficial wound infection (n=2). Arm edema was observed in 3 patients which resolved spontaneously within 2 weeks in 2 of them, and persisted in one who developed severe venous hypertension 6 months after the procedure due to underlying undiagnosed subclavian vein stenosis and was managed by balloon angioplasty and stenting. Severe bleeding from a ruptured access ended by ligation of one access after 4 months.

Five cases developed access stenoses throughout the follow up period and all were treated by balloon angioplasty. Patency was restored successfully in 3 cases. Further restenosis was encountered in 1 case after 6 months, in which re-angioplasty was not successful due to failure to cross the lesion. The most common encountered complications are summarized in table 2. At 6, 12, 18, 24 months, primary patency rates were 83.3%, 77.7%, 72.2%, 61.1% and secondary patency rates were 88.8%, 83.3%, 77.7%, 66.6% **(Figure 5)**.

Table 2: Complications encountered during the study

	Complications	*Early < 30 days*		*Late > 30 days*	
		Patient Number	**Management**	**Patient Number**	**Management**
1	**Bleeding:**				
	- **Mild**	1	Conservative	---	---
	- **Severe**	---	---	1	Access loss (ligation)
2	**Vascular steal (grade 1)**	1	Conservative	---	---
3	**Superficial wound infection**	2	Conservative	---	---
4	**Venous hypertension :**				
	- **Mild (arm oedema)**	2	Conservative	---	---
	- **Severe**	---	---	1	PTA & stenting
5	**Thrombosis**	---	---	2	Access loss
6	**Pseudo-aneurysm at needling site**	-	-	3	Conservative
7	**Access Stenosis**	-	-	5	PTA (successful in 3 cases)
	Re-stenosis	-	-	1	PTA (Access loss)

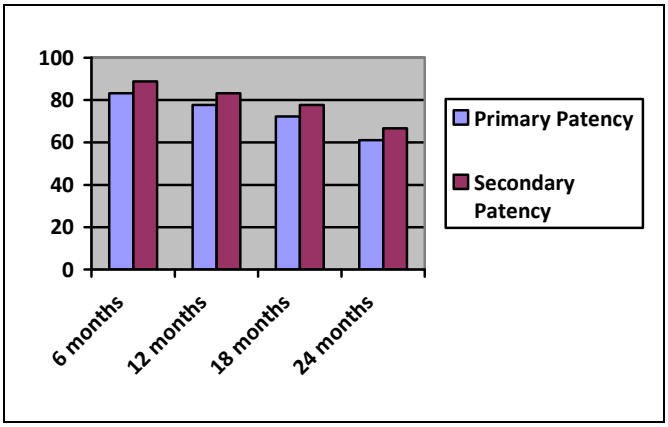

Fig. 5: Primary & Secondary patency rates

DISCUSSION

Each VA that fails; brings hemodialysis patient one step closer to a "terminal access" problem, a point where all roads seem closed. [7,8] This fact is especially augmented when a complicated access mandates ligation of the brachial artery resulting in -not only- access failure, but also, it eventually results in loss of 50% of the safe anatomical AV access sites as this upper limb is going to be abandoned.

In patients with AV access-related extensive infection at the elbow level, brachial artery ligation is considered the mainstay treatment especially when life threatening bleeding is impending from an involved arteriotomy site. [9,10] In such situations, most of the limbs are compensated, as ligation is usually performed distal to the origin of both the profunda brachii and the superior ulnar collateral arteries. However, the development of distal chronic ischemia in these cases cannot be ignored [11,12], and some of them may require additional interventions.[13,14]

Although most limbs with ligated brachial artery can skip drastic ischemic consequences, yet they are considered out of use for further AVF construction. Hence, the concept of reconstructing a previously ligated brachial artery might be appealing to prepare limbs for future AVF construction rather than improving the vascularity of the limb. This is supported by *Nicholas et al* study [15] and the likelihood of developing low output steal after AVF construction in patients with peripheral vascular disease. [16]

In the current study, which included relatively younger patients on long term hemodialysis and multiple attempts of access construction before, a harvested segment of GSV was evaluated when used not only for reconstruction of a previously ligated brachial artery, but also for the construction of a new AVF.

Being an auto-graft, GSV presents an easy handling low cost conduit with higher infection resistance and better overall results at least theoretically. The well developed muscle layer of GSV wall carries the advantage of minimized subsequent aneurysmal dilatation. However, this histological nature increases the risk of myointimal hyperplasia when exposed to the repeated punctures in hemodialysis sessions. [17] Detailed venous mapping of such patients was mandatory to select those having good caliber vein greater than 3 mm in diameter due to the high resistance of GSV in general and small caliber in particular to dilate after arteriovenous fistula creation. [18]

Several techniques have already described the insitu use of GSV in construction of lower extremity AVFs when upper limb options are exhausted. However, the high incidence of co-existing lower extremities arterial occlusive disease and groin access-related infections limit the use of such techniques. [19] So, the use of GSV translocation to the upper limb for AVF creation might be an attractive option, [22] but *Smith et al.,* reported that this option is still under-used. This could be explained by the fact that a synthetic graft looks more practical regarding its larger caliber and rapid tissue incorporation.[20] This explanation sounds logic except if the brachial artery needs to be reconstructed at the same time, in such settings the valuable role of the GSV is evoked once more.

Both brachial artery reconstruction and new AVF construction could be done either on a single or staged procedure basis. The first option does solve the problem completely and relieves patients from long term catheter related complications; and this was adopted in this study. However, staged procedure has also its role in reviving the limb back to the field of access sites creation whenever needed later on.

From the technical point of view, it is important to denote the importance of gentle dissection of the arterial stumps as near as possible to the site of previous ligation. This did not only minimize the needed length of harvested GSV, but also it minimized collateral jeopardize. In the current study, arterial reconstruction, in all patients, remained patent all over the whole follow up period. One patient had grade I vascular steal who was managed conservatively.

The most common indication for re-intervention was access stenosis that was encountered in 5 patients who underwent successful balloon angioplasty in 3 of them; and this improved the secondary patency rate. The secondary patency rate was similar to the results obtained with prosthetic AV grafts, which is acceptable for patients in whom VA is difficult.[23]

The operative time and the relative complexity of the procedure are cheap price to revive an

abandoned limb back to work for improving the quality of life in such suffering patients.

CONCLUSION

Simultaneous brachial artery reconstruction and new fistula construction using great saphenous conduit in limbs with previously ligated brachial artery proved to be feasible and safe with reasonable outcome. It offers a valid autologous alternative in some patients with limited vascular access options as a bail-out procedure before embarking to more sophisticated options.

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