Outcomes of brachiobasilic arteriovenous shunting with superficialization as a vascular access for renal dialysis: an early experience in Benha University

El-Sayed A. Abd El-Mabood[a], Mokhtar A. Bahbah[a], Ayman M. Adbelmofeed[a], Hazem E. Ali[a], M. Hamed Abd El-Fattah[b], Mohamed I. Hasan[c]

Departments of [a]General Surgery, [b]Anesthesia and Intensive Care, [c]Radiology, Benha University, Benha, Egypt

Correspondence to El-Sayed A. Abd El-Mabood, MD, Department of General Surgery, Benha University, 3A Elharamen Pharmacy Street, Benha, Egypt
Tel: +0133265694;
e-mail: elsayedafifi@yahoo.com

Received 20 March 2014
Accepted 2 April 2014

The Egyptian Journal of Surgery
2014, 33:146–153

Purpose
The aim of the study was to assess outcomes of brachiobasilic arteriovenous fistula (BBAVF) under ultrasound (US)-guided supraclavicular block with or without superficialization and of brachiocephalic arteriovenous fistula in patients with vessels unsuitable or failed for a forearm fistula.

Patients and methods
The study included 75 patients diagnosed with end-stage renal failure. They were divided into three equal groups (n = 25) according to the site of fistula: group 1 underwent BBAVF (one-stage), group 2 underwent BBAVF (two-stage with 1-month interval), and group 3 underwent brachiocephalic arteriovenous fistula, all with end-to-side anastomosis under US-guided supraclavicular block.

Results
There was significant difference in the diameter of arm veins between the first two groups and the third group (P = 0.01), especially using supraclavicular block. Despite group 1 had the longest operative time (82.02 ± 11.39), it had the shortest duration of maturation and the best mean flow rate (ml/min) (P = 0.0004 and 0.004, respectively). The frequency of early postoperative complications — that is, primary access failure and early thrombosis (first 10 days) — and late complications — that is, late thrombosis more than 10 days and pseudoaneurysm — was less in group 1 (P = 0.05).

Conclusion
Despite one-stage BBAVF takes long operative time, it appears to be the most ideal vascular access, with high success rate, shortest duration of maturation, best mean flow rate, and less postoperative complications, and surgical redo with its complications is also less especially using US-guided supraclavicular block.

Keywords:
arteriovenous fistula, outcomes, renal dialysis, superficialization, ultrasound-guided supraclavicular block

Egyptian J Surgery 33:146–153

1110-1121

Introduction

In recent years, the number of patients requiring hemodialysis (HD) has been rapidly increasing globally; arteriovenous fistula (AVF) is the most frequently used method in patients with end-stage renal failure (ESRF) for HD [1].

The Kidney Disease Outcome Quality Initiative recommends autologous radiocephalic or brachiocephalic arteriovenous fistula (BCAVF) as a primary method of choice in HD patients and basilic vein transposition as a secondary option [2].

Placement of an autogenous AVF for dialysis is an important step in end-stage renal disease patients. Dialysis access is a lifeline for such patients; hence, its maturation and continued function are crucial for overall well-being [3].

Fistula maturation is a general term used to refer to multiple processes that occur from the time of surgical fistula construction HD access until the time the AVF becomes functional [4].

The desired end result of fistula maturation is a high-flow, large-caliber, superficial vessel with robust wall structure suitable for repeated reliable dialysis needle access [5]. Criteria for assessment of maturation have been proposed as the role of sixes, which states that, by 6 weeks after surgical creation, the fistula should measure 6 mm or greater in diameter, 6 mm or less deep from the skin surface, with flow of 600 ml/min or more and a usable length of 6 cm or more; these parameters are relatively easy to quantitate and provide a useful starting point for assessment of fistula maturity [6].

The first step in the process of creating a high-quality functional AVF is a well-performed surgical construction utilizing the artery–vein pair based upon appropriate clinical and/or ultrasound (US) preoperative vascular assessment [7]. Patients with chronic renal failure may suffer from serious complications that represent a great challenge to the anesthesiologists. Complications such as congestive heart failure, systemic hypertension, electrolyte imbalances, metabolic acidosis, coagulopathy, unpredictable intravascular fluid volume status, and anemia obligate the anesthesiologist to avoid general anesthesia with its heroic risks in these patients and to think for alternative methods [8].

Brachial plexus block is often used in chronic renal failure patients to provide anesthesia for the creation or revision of AVF for HD access. It provides analgesia, sympathetic blockade, optimal surgical conditions, and adequate duration of postoperative block that prevents arterial spasm and graft thrombosis. It provides higher blood flow in the radial artery and AVF than is achieved with infiltration anesthesia [9].

Many approaches can be used for brachial plexus block: axillary, supraclavicular, and infraclavicular approaches. They were commonly performed by blind techniques or neurostimulation, which may be associated with high failure rate and serious complications. Nowadays, the intraoperative use of ultrasonography has become more popular and much easier. Its use in these blocks increases the success rate and decreases complications [10].

Patients and methods

After local ethical committee of Benha University approval and obtaining written fully informed patients consent, the current study was conducted at the General Surgery Department, Benha University Hospital from March 2011 to August 2013 so as to allow 6-month follow-up period for the last case operated on. This prospective randomized controlled study was conducted on 75 patients diagnosed with ESRF ASA III, including 43 (57.3%) male patients and 32 (42.7%) female patients with age strata; most patients were aged between 40 and 60 years (n = 45, 60%). Patients were randomly allocated using a computer-generated random number table into three equal groups according to the site of fistula: group 1 that underwent brachiobasilic arteriovenous fistula (BBAVF) (one-stage) (n = 25), group 2 that underwent BBAVF (two-stage with 1-month interval) (n = 25), and group 3 that underwent BCAVF (n = 25), all with end-to-side anastomosis under US-guided supraclavicular block, if failed local infiltration anesthesia. Postoperative follow-up was 3–6 months.

All patients presenting were subjected to detailed clinical evaluation, laboratory assessment, and arterial and venous duplex US imaging study with vessel mapping for assuring the preparation.

Patients with both patent basilic and cephalic veins greater than 3 mm of diameter as well as with triphasic arterial inflow were randomly arranged to the BBAVF and BCAVF groups by computerized allocation. All fistulae were placed in patients with vessels unsuitable for a forearm fistula or with a failed forearm fistula.

Exclusion criteria in this study included previous BBAVF or BCAVF, age younger than 18 years, less than 3 mm of diameter of the brachial artery at the elbow, absence of radial or ulnar artery pulses, less than 3 mm of diameter of the basilic and cephalic veins in any location in the upper arm, inability to obtain patient consent or refusal of the patient to undergo US-guided supraclavicular block, and history of hypersensitivity reaction to local anesthesia or coagulation disorder.

Operative procedure

All procedures were performed under US-guided supraclavicular block performed by an anesthesiologist and radiologist using US machine (Chison L45607S, China) with curved-array probe (7.5 MHz).

The patient was placed in the supine position with head tilted to the opposite side; the skin was disinfected; transducer was positioned in the transverse plane superior to the midpoint of the clavicle, tilted inferior to obtain the cross-section view; a 25–27-G needle was used, with insertion not more than 1 cm to avoid injury to the brachial plexus; and the needle place was confirmed by motor response or nerve stimulation using (0.5 mA, 0.1 ms) injection of 25–30 ml of l-bubivacaine. Intraoperative duplex ultrasonography was used to assess the diameter of vein before and after block.

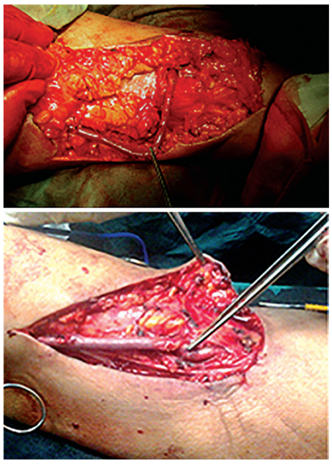
In group 1, the incision was performed through the basilic vein located in the medial condyle of the humerus and axillary area. The vein was carried over the fascia by tying the lateral branches during release of the basilic vein, whereas the medial cutaneous nerve of the forearm was preserved. The basilic vein in the antecubital fossa was anastomosed to the brachial artery end-to-side, using 6-0 or 5-0 polypropylene continuous sutures. Following evaluation of the presence of thrill, the fascia and other layers were closed, lifting the vein and protecting the nerve. One and a half month was allowed for the anastomosed graft to heal before the possible trauma of HD injection [11–13] (Fig. 1).

In group 2, the incision was made through the basilic vein located in the medial and lateral condyle of the humerus and was anastomosed to the brachial artery laterally using 6-0 or 5-0 polypropylene continuous suture. The incisions were closed in the anatomical layers after the presence of thrill was evaluated. In the next stage at 1 month, an incision was made through the basilic vein located in the medial condyle of the humerus and the axillary area. The vein was carried over the fascia by tying the lateral branches during the release of the basilic vein, whereas the medial cutaneous nerve of the forearm was preserved. Following the evaluation of the presence of thrill, the fascia and other layers were closed in anatomical layers, lifting the vein and protecting the nerve. Patients whose wounds had healed after 40 days underwent HD [14–16] (Fig. 2).

In group 3, BCAVFs were created by making a transverse incision just proximal to the elbow as previously described elsewhere. The cephalic vein was dissected free and transected at the level of elbow. Subsequently, the anastomosis was performed as described in BBAVF. Additional care was taken to secure hemostasis at the end of the procedure. The systemic heparin was not used either intraoperatively or postoperatively [11,17] (Fig. 3).

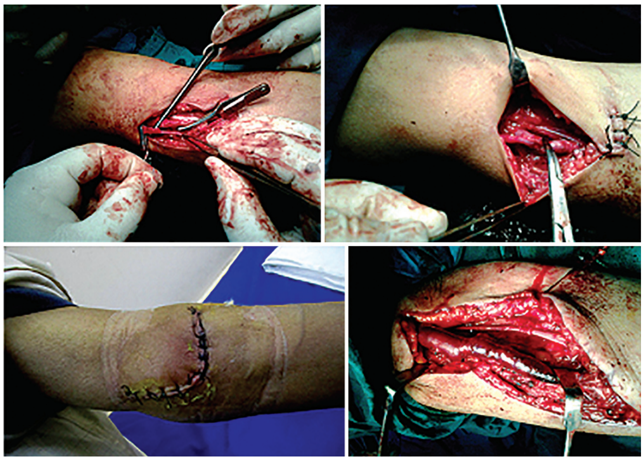
Technical success was defined as the presence of a palpable thrill on the fistula at completion of the procedure and 24 h postoperatively.

Figure 1



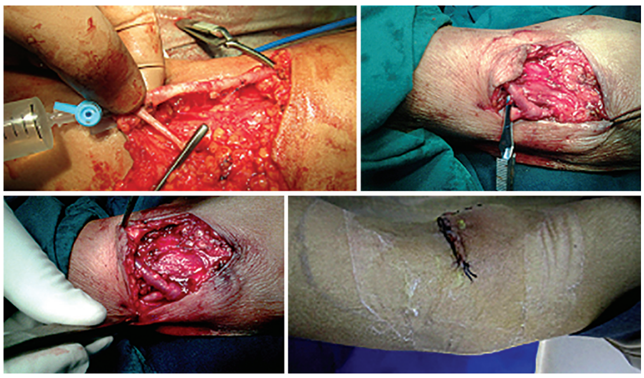
Brachiobasilic arteriovenous fistula (one-stage).

Figure 2



Brachiobasilic arteriovenous fistula (two-stage): first stage and second stage.

Figure 3



Brachiocephalic arteriovenous fistula.

Outcome items

Postoperative follow-up was performed for duration of maturation (mean) (days), mean flow rate (ml/min), and complications, either early complications that included primary access failure (by early thrombosis), bleeding, or hematoma or late complications that included late thrombosis, pseudoaneurysm (circumscribed dilatation, either fusiform or saccular, of a vascular access more than twice of diameter of the preceding and following segments of access; when the aneurysm becomes rapidly enlarged, inflamed, or symptomatic, ligation was undertaken to prevent rupture and bleeding) [13], steal syndrome, or wound infection.

All interventions were recorded, such as mechanical thrombectomy, aneurysm ligation, and successful endovascular treatment, but when failure is inevitable surgical revision was performed.

Statistical analysis

Analysis of data was performed using SPSS version 16 (Bristol university; UK). Quantitative data were presented as mean and SD and were analyzed by analysis of variance test. Qualitative data was presented as numbers and percentages and were analyzed using the χ^2-test. P-value less than 0.05 was considered significant and P-value less than 0.01 was considered highly significant, whereas *P*-value greater than 0.05 was considered insignificant.

All data were recorded in the following images: Fig. 1 for group 1, Fig. 2 for group 2, and Fig. 3 for group 3.

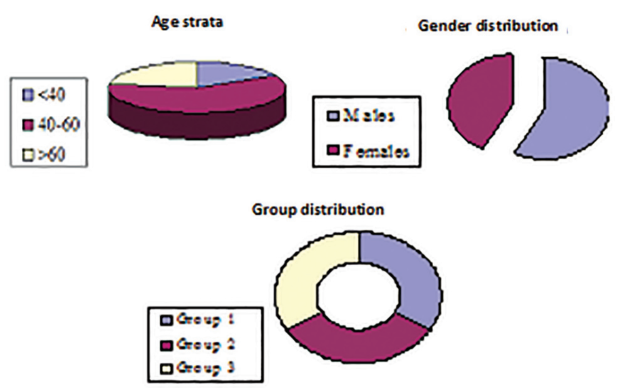
Results

This study included 75 patients who were diagnosed with ESRF, 43 (57.3%) male patients and 32 (42.7%) female patients with age strata; most patients were aged between 40 and 60 years (*n* = 45, 60%). Patients of this study were divided into three equal groups according to the site of fistula: group 1 that underwent BBAVF (one-stage) (*n* = 25), group 2 that underwent BBAVF (two-stage with 1-month interval) (*n* = 25), and group 3 that underwent BCAVF (*n* = 25). Associated morbidities — that is, diabetes, hypertension, or smoking — had no significance (Table 1 and Graph 1).

Most of the fistulae of this study were located at nondominant arm, group 1: 20 (80%), group 2: 21 (84%), and group 3: 19 (76%), and most of them were performed in the first month after dialysis, group 1: 24 (96%), group 2: 22 (88%), and group 3: 24 (96%). There were some patients who had previous access dialysis (Table 2 and Graph 2).

Diameter of the arm veins was greater than 3 mm with respect to the first two groups (*P* = 0.01): basilic vein, 3.9 ± 0.88, and cephalic vein, 3.44 ± 0.14; this can be explained by the fact that cephalic vein is more superficial, and hence is more exposed to the repeated intravenous injection, more fibrosis, and narrowing, but basilic vein is deep. After US brachial plexus block, there was dilatation of the vein diameter significantly, especially the basilic one (4.21 ± 0.93) (*P* = 0.0033, highly significant); this depends on the fact that cephalic vein is exposed to fibrosis, and hence

Graph 1



Preoperative data.

Table 1 Preoperative data

Preoperative data	Group 1	Group 2	Group 3	χ^2	*P*
Age (years)					
<40	13 (17.3)				
40–60	45 (60)				
>60	17 (22.7)				
Sex					
Male	43 (57.3)				
Female	32 (42.7)				
Site of AV fistula	BBAVF (one-stage) (*n* = 25)	BBAVF (two-stage with 1-month interval) (*n* = 25)	BCAVF (*n* = 25)		
Diabetes	6 (24)	8 (32)	9 (36)	0.8	0.6
Hypertension	12 (48)	17 (68)	15 (60)	2.08	0.35
Smoking	4 (16)	5 (20)	3 (12)	0.59	0.74

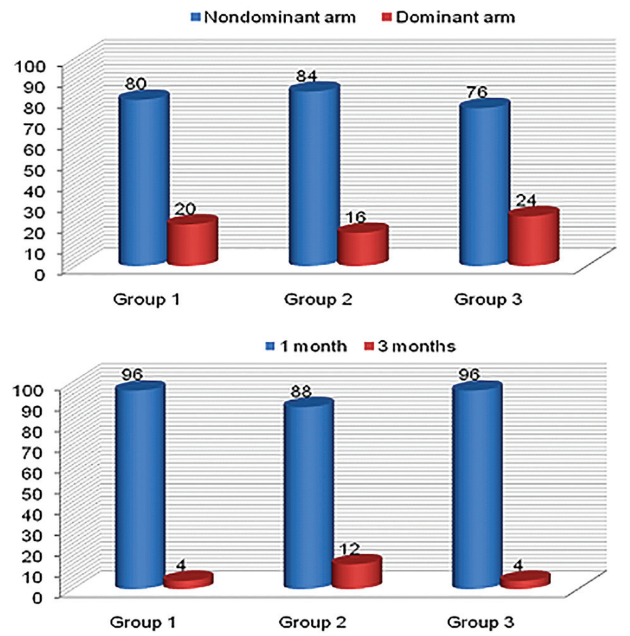
AV, arteriovenous; BBAVF, brachiobasilic arteriovenous fistula; BCAVF, brachiocephalic arteriovenous fistula.

Table 2 Fistula characteristics of patients with brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula

Fistula characteristics of patients	Group 1	Group 2	Group 3	χ^2	*P*
Location of AVF [*n* (%)]					
Nondominant arm	20 (80)	21 (84)	19 (76)	0.5	0.77
Dominant arm	5 (20)	4 (16)	6 (24)		
Timing of AVF in advance of dialysis [*n* (%)]					
1 month	24 (96)	22 (88)	24 (96)	1.7	0.42
3 months	1 (4)	3 (12)	1 (4)	1.7	0.42
Previous access dialysis	3 (12)	4 (16)	2 (8)	0.76	0.68

AVF, arteriovenous fistula.

Graph 2



Fistula characteristics of patients with brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula. AVF, arteriovenous fistula.

has less elasticity and distensibility — that is, basilic vein is better for anastomosis especially with the use of brachial plexus block [18]. However, there was no difference in brachial artery diameter before and after brachial plexus block (Table 3).

All patients underwent end-to-side anastomosis, with longest operative time in group 1 (82.02 ± 11.39), followed by group 2 (62.34 ± 3.17), and then group 3 (59.68 ± 9.16) (P = 0.00000045, highly significant compared with BCAVF). However, postoperative early revision was performed in three (12%) patients in group 1, one (4%) patient in group 2, and two (8%) patients in group 3; hence, the revision was insignificant (P = 0.58). Early revision was performed for massive leaking anastomosis or very narrow anastomosis affecting distal pulsation that might end by distal gangrene (Table 4).

Patients passed postoperative period and followed up for duration of maturation (mean) (days) (known by dialysis injection without hematoma or leaking), with group 1: 42 ± 14 days, group 2: 69 ± 23 days, and group 3: 45 ± 13 days; the maturation was highly significant toward group 1 (P = 0.0004). The mean flow rate (ml/min) was measured by duplex ultrasound, with group 1: 330 ± 26, group 2: 299 ± 32, and group 3: 310 ± 21; the rate was highly significant toward group 1 (P = 0.004) (Table 5).

Early postoperative complications — that is, primary access failure (very narrow anastomosis or early thrombosis) and early thrombosis (first 10 days) — were less in group 1; primary access failure was observed in one (4%) patient in group 1, three (20%) patients in group 2, and seven (28%) patients in group 3 (P = 0.05). Similar results were found in early thrombosis (P = 0.02). However, there was no significance in other early postoperative complications — that is, bleeding or hematoma — in all groups (P = 0.58 and 0.76, respectively) (Table 6 and Graph 3).

However, late postoperative complications — that is, late thrombosis more than 10 days and pseudoaneurysm — were less in group 1; late thrombosis was observed in two (8%) patients in group 1, six (24%) patients in group 2, and nine (36%) patients in group 3 (P = 0.05). Similar results were found in pseudoaneurysm (P = 0.05). However, there was no significance in other late postoperative complications — that is, steal syndrome or wound infection — in all groups (P = 0.85 and 0.8, respectively) (Table 7 and Graph 4).

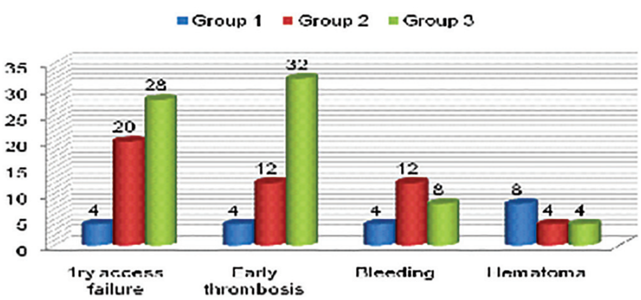
Finally, the success rate of AVF was significant (P = 0.03) in group 1, 23 (92%), with highest number of successful cases, followed by group 2, 18 (72%), and then group 3, 15 (60%); the patients with complications were treated well either by only mechanical thrombectomy (Fig. 4) (P = 0.03) or by aneurysm ligation (P = 0.15) or endovascular treatment (P = 0.7). However, in patients with inevitable failure, surgical revision was the treatment (P = 0.02) (Table 8 and Graph 5).

Table 3 Vascular characteristics of patients with brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula

Vascular characteristics of patients	Group 1	Group 2	Group 3	F	P
Diameter of vein before block (mm)	3.9 ± 0.88		3.44 ± 0.14	2.6	0.01
Diameter of vein after block (mm)	4.21 ± 0.93		3.54 ± 0.12	3.09	0.0033
Diameter of vein after local infiltration (mm)	3.9 ± 0.87		3.44 ± 0.14	2.6	0.01
Diameter of brachial artery before block (mm)	4.83 ± 1.5		4.85 ± 1.1	0.05	0.95
Diameter of brachial artery after block (mm)	4.83 ± 1.5		4.85 ± 1.1	0.05	0.95

Data are presented as mean ± SD.

Graph 3



Postoperative early complications in brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula.

Table 4 Perioperative characteristics in patients with brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula

Operative characteristics	Group 1	Group 2	Group 3	Test	P
Operative time (min)	82.02 ± 11.39	62.34 ± 3.17	59.68 ± 9.16	F = 11.4	0.00000045
Postoperative early revision	3 (12)	1 (4)	2 (8)	χ^2 = 1.08	0.58

Data are presented as mean ± SD and numbers (percentages are given in parentheses).

Table 5 Postoperative data in patients with brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula

Postoperative data	Group 1	Group 2	Group 3	*F*	*P*
Duration of maturation (days)	42 ± 14	69 ± 23	45 ± 13	4.5	0.0004
Mean flow rate (ml/min)	330 ± 26	299 ± 32	310 ± 21	2.9	0.004

Data are presented as mean ± SD.

Table 6 Postoperative early complications in brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula

Postoperative early complications	*n* (%)			χ^2	*P*-value
	Group 1	Group 2	Group 3		
Primary access failure	1 (4)	3 (12)	7 (28)	5.9	0.05
Early thrombosis	1 (4)	3 (12)	8 (32)	7.7	0.02
Bleeding	1 (4)	3 (12)	2 (8)	1.08	0.58
Hematoma	2 (8)	1 (4)	1 (4)	0.52	0.76

Table 7 Postoperative late complications in brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula

Postoperative late complications	*n* (%)			χ^2	*P*
	Group 1	Group 2	Group 3		
Late thrombosis>10 days	2 (8)	6 (24)	9 (36)	5.8	0.05
Pseudoaneurysm	1 (4)	3 (12)	7 (28)	5.9	0.05
Steal syndrome	3 (12)	2 (8)	2 (8)	0.31	0.85
Wound infection	1 (4)	2 (8)	2 (8)	0.4	0.8

Table 8 Postoperative access intervention/first year in brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula

Postoperative access intervention	*n* (%)			χ^2	*P*
	Group 1	Group 2	Group 3		
None (successful AVF)	23 (92)	18 (72)	15 (60)	6.9	0.03
Only mechanical thrombectomy	1 (4)	4 (16)	8 (32)	6.8	0.03
Aneurysm ligation	0 (0)	1 (4)	2 (8)	3.6	0.15
Successful treatment	1 (4)	1 (4)	2 (8)	0.5	0.7
Failed AVF needed surgical revision	1 (4)	3 (12)	8 (32)	7.7	0.02

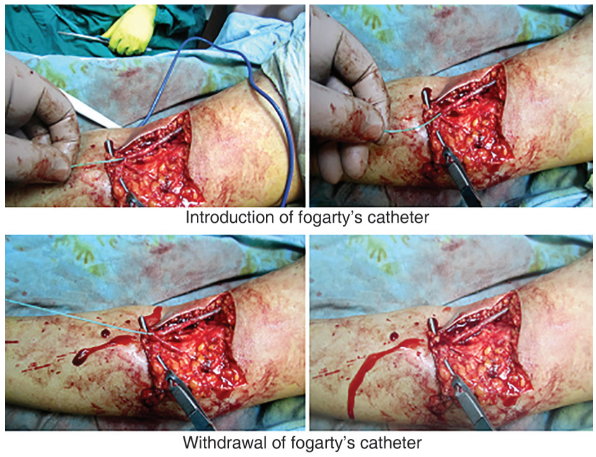
AVF, arteriovenous fistula.

Discussion

Patients with ESRF must receive HD to survive until they undergo renal transplantation. AVF surgery to supply extracorporeal blood flow has been performed for many years during HD [18]. The optimal flow rate is at least 200 ml/min with an easy-to-use device, providing sufficient supply in a durable and safe procedure [19,20]. For this purpose, arteries and veins of the upper limbs are mostly used.

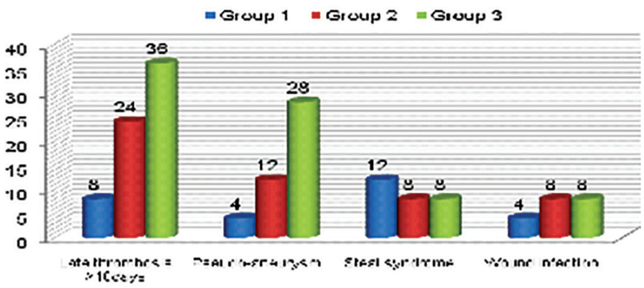
There are several theoretical advantages of selecting the basilic vein over the cephalic vein when considering AVF creation [21]. Unlike other veins in the arm, the basilic vein is naturally deep, protected from damage caused by previous venepuncture, and has a larger diameter [22]. However, these anatomical advantages lead to a more demanding, complex surgical dissection and prolong surgery. To manage these technical factors, the procedure is often performed under general anesthesia [23]. In this study, general anesthesia was replaced by US-guided brachial plexus block, which provided very satisfactory sensory and motor block in patients with chronic renal failure undergoing creation of AVF of the distal upper extremity [24].

Figure 4



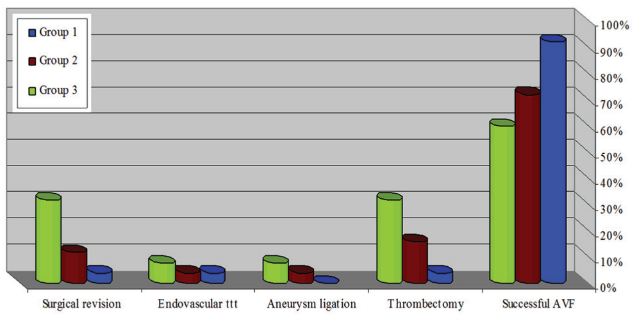
Mechanical thrombectomy.

Graph 4



Postoperative late complications in brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula.

Graph 5



Postoperative access intervention/first year in brachiobasilic arteriovenous fistula and brachiocephalic arteriovenous fistula. AVF, arteriovenous fistula; ttt, treatment.

This block provided very good analgesia that extended for a long time postoperatively. Patients were satisfied with this block, and no complications were reported. In addition, this helps a lot when a local cause such as swelling, infection, or obesity prevents the use of either of them. Hence, the other approach would work [25]. Moreover, brachial plexus block can induce dilatation of veins especially the basilic vein as the cephalic vein being exposed to repeated venepuncture; it is more fibrosed with less dispensability [26] in addition to this block gives the advantages of local anesthesia; safety, decrease len gth of hospitalization, and relatively low cost [27].

The proper location of AVFs and shunts must allow for the identification of landmarks to ensure successful needle access. Traditionally, AVFs located too deeply are superficialized with a formal surgical procedure. This procedure necessitates a larger incision and requires an extended healing time before the fistula may be accessed [28]. The current study evaluated the clinical outcomes of three types of upper arm vascular access; group 1 underwent one-stage BBAVF with superficialization and group 2 underwent two-stage BBAVF [29]. BBAVF upper arm fistulas had a substantially lower primary failure rate (suitability failure) and less early thrombosis — group 1, one (4%), and group 2, three (20%) — compared with BCAVFs — group 3, seven (28%) (P = 0.05) [30]. These results were mentioned by Silva *et al.* [31,32] who had reported a markedly lower primary failure rate of BBAVF.

One-stage BBAVF was superior to two-stage BBAVF because of its lower rate of postoperative early and late complications and higher early fistula maturation with better flow rate, despite its disadvantage of long operation time that needs general anesthesia, which was overcome by US-guided brachial plexus block in this study. This was due to larger diameter of the basilic vein observed in patients who underwent one-stage BBAVF, which led to decrease in postoperative complications and helped fistula maturation; this was mentioned by Kakkos *et al.* [1].

There were many factors affecting the fistula maturation in addition to vein diameter; postoperative hematoma and venous hypertension may be more important than the diameter of the vein. There was no significance in this finding in the three groups (P = 0.76 and 0.85, respectively) [22,33,34].

With respect to auxiliary interventions, the rate of intervention in group 1 was significantly less: only mechanical thrombectomy in one (4%) patient (P=0.03) and surgical revision in one (4%) patient (P = 0.02). There was no statistically significant difference in auxiliary interventions due to pseudoaneurysm (P = 0.15) and steal syndrome (P = 0.85) between the three groups.

In conclusion AVF formation using BBAVF is a compelling procedure for the surgeon to avoid possible complications, including loss of function, infection, distal ischemia, and venous edema. Despite one-stage BBAVF takes long operative time, it appears to be the most ideal vascular access, with high success rate, less duration of maturation, best mean flow rate, and less postoperative complications — that is, primary access failure, thrombosis, or pseudoaneurysm — especially using US-guided supraclavicular block. One-stage BBAVF performed under US-guided supraclavicular block is of special importance in obese patients, and surgical redo with its complication is also less.

Acknowledgements

Conflicts of interest

None declared.

References

1 Kakkos SK, Haddad GK, Weaver MR, Haddad RK, Scully MM. Basilic vein transposition: what is the optimal technique? Eur J Vasc Endovasc Surg 2010; 39:612–619.

2 Foundation NK. KDOQI clinical practice guidelines and clinical practice recommendations for 2006 updates: hemodialysis adequacy, peritoneal dialysis adequacy and vascular access. Am J Kidney Dis. 2006; 48 (Suppl 1):1–322.

3 Meier GH: Hemodialysis Access: *Failing and Thrombosed Cronenwett: Rutherford's Vascular Surgery,* 7th ed. 1127-1136 Copyright © 2010 Saunders, an Imprint of Elsevier.

4 Besarab A, Work J: Clinical practice guidelines for vascular access. Am J Kidney Dis 48 Suppl.; 2006; 1:177: 247.

5 Depner T, Daugirdas J: Clinical practice guidelines for hemodialysis adequacy. Am J Kidney Dis; 48 Suppl.; 2006; 1:1: 90.

6 Mandolfo S, Borlandelli S, Ravani P, Imbasciati E. How to improve dialysis adequacy in patients with vascular access problems. J Vasc Access; 2006; 7: 53–59.

7 Stijnen T, Tordoir J, Burgmans J, *et al.* Radio-cephalic wrist arteriovenous fistula for hemodialysis: meta-analysis indicates a high primary failure rate. Eur J Vasc Endovasc Surg; 2004; 28: 583–589.

8 Holt NF. Renal disease. In: Hines RL, Marschall KE, editors. *Stoelting's anesthesia and co-existing disease*, 6th ed.; 2012; 339–356.

9 Sahin L, Gul R, Mizrak A, *et al.* Ultrasound-guided infraclavicular brachial plexus block enhances postoperative blood flow in arteriovenous fistulas. J Vasc Surg 2011; 54:749–753.

10 Arcand G, Williams SR, Chouinard P, *et al.* Ultrasound-guided infraclavicular versus supraclavicular block. Anesth Analg 2005; 101:886–890.

11 Mackrell PJ, Cull DL, Carsten III CG. Hemodialysis access: placement and management of complications. In: Hallett Jr JW, Mills JL, Earnshaw JJ, Reekers JA, editors. *Comprehensive vascular and endovascular surgery*. 1st ed. Edinburg: Mosby; 2004. 361–390.

12 Sidawy AN, Gray R, Besarab A, Henry M, Ascher E, Silva M Jr, *et al.* Recommended standards for reports dealing with arteriovenous hemodialysis accesses. J Vasc Surg 2002; 35:603–610.

13 Diskin C, Stokes TJ, Dansby LM, Radcliff L, Carter TB. Doxycyline may reduce the incidence of aneurysm in hemodialysis vascular accesses. Nephrol Dial Transplant 2005; 20:959–961.

14 Ascher E, Hingorani A, Gunduz Y, Yorkovich Y, Ward M, Miranda J, *et al.* The value and limitations of the arm cephalic and basilic vein for arteriovenous access. Ann Vasc Surg 2001; 15:89–97.

15 Rao RK, Azin GD, Hood DB, Rowe VL, Kohl RD, Katz SG, *et al.* Basilic vein transposition fistula: a good option for maintaining hemodialysis access site options? J Vasc Surg 2004; 39:1043–1047.

16 Choi HM, Lal BK, Cerveira JJ, Padberg FT, Silva MB, Hobson RW, *et al.* Durability and cumulative patency functional patency of transposed and nontransposed arteriovenous fistulas. J Vasc Surg 2003; 38:1206–1212.

17 Segal JH, Kayler LK, Henke P, Merion RM, Leavey S, Campbell DA. Vascular access outcomes using the transposed basilic vein arteriovenous fistula. Am J Kidney Dis 2003; 42:151–157.

18 Gelabert HA, Freischlag JA Hemodialysis access. In: Rutherford RB, editor. *Vascular surgery* 7th ed. Philadelphia: WB Saunders; 2010. 1466–1477.

19 Madran H, Ozgur B, Kursad S, Sakarya A, Erhan Y, Aydede H. Vascular interventions in chronic hemodialysis. Türkiye Klinikleri Kalp Damar Cer Derg. 2001; 2:38–47.

20 Saritas B, Okyay K, Yilmazturk H. Perforating vein-brachial artery anastomosis as an alternative to conventional arterio-venous fistulae for hemodialysis: mid-term follow-up results. Türkiye Klinikleri J Cardiovasc Sci. 2010; 22:200–205.

21 Dix FP, Khan Y, Al-Khaffaf H. The brachial artery-basilic vein arteriovenous fistula in vascular access for haemodialysis – a review paper. Eur J Vasc Endovasc Surg 2006; 31:70–79.

22 Woo K, Farber A, Doros G, Killen K, Kohanzadeh S. Evaluation of the efficacy of the transposed upper arm arteriovenous fistula: a single institutional review of 190 basilic and cephalic vein transposition procedures. J Vasc Surg 2007; 46:94–101.

23 Fitzgerald JT, Schanzer A, Chin AI, McVicar JP, Perez RV, Troppmann C. Outcomes of upper arm arteriovenous fistulas for maintenance hemodialysis access. Arch Surg 2004; 139:201–208.

24 Fredrickson MJ, Patel A, Young S, Chinchanwala S. Speed of onset of 'corner pocket supraclavicular' and infraclavicular ultrasound guided brachial plexus block: a randomized observer-blinded comparison. Anaesthesia 2009; 64:738–744.

25 Koscielniak-Nielsen ZJ, Frederiksen BS, Rasmussen H, *et al.*. A comparison of ultrasound-guided supraclavicular and infraclavicular blocks for upper extremity surgery. Acta Anesthesiol Scand 2009; 53:620–626.

26 Sandhu NS, Manne JS, Medabalmi PK, Capan LM. Sonographically guided infraclavicular brachial plexus block in adults: a retrospective analysis of 1146 cases. J Ultrasound Med 2006; 25:1555–1561.

27 Perlas A, Lobo G, Lo N, *et al.* Ultrasound guided supraclavicular block: outcome of 510 consecutive cases. Reg Anesth Pain Med 2009; 34:171–176.

28 Cull DL, Taylor SM, Carsten CG, *et al.* The fistula elevation procedure: a valuable technique for maximizing arteriovenous fistula utilization. Ann Vasc Surg 2002; 16:84–88.

29 Francis DM, Lu Y, Robertson AJ, Millar RJ, Amy J. Two-stage brachiobasilic arteriovenous fistula for chronic haemodialysis access. ANZ J Surg. 2007; 77:150–155.

30 Oliver MJ, McCann RL, Indridason OS, Butterly DW, Schwab SJ. Comparison of transposed brachiobasilic fistulas to upper arm grafts and brachiocephalic fistulas. 2001; Kidney Int 60: 1532–1539.

31 Silva MB, Hobson RW, Pappas PJ, Araki CT, Goldberg MC, Jamil Z, Padberg FT. Vein transposition in the forearm for autogenous hemodialysis access. J Vasc Surg 1997; 26:981–988.

32 Silva MB, Hobson RW, Pappas PJ, Jamil Z, Araki CT, Goldberg MC, *et al.* A strategy for increasing use of autogenous hemodialysis access procedures: impact of preoperative noninvasive evaluation. J Vasc Surg. 1998; 27:302–307.

33 Wolford HY, Hsu J, Rhodes JM, Shortell CK, Davies MG, Bakhru A *et al.* Outcome after autogenous brachial-basilic upper arm transpositions in the post-National Kidney Foundation Dialysis Outcomes Quality Initiative era. J Vasc Surg. 2005; 42:951–956.

34 Berman SS, Gentile AT: Impact of secondary procedures in autogenous arteriovenous fistula maturation and maintenance. J Vasc Surg 2001; 34:866–871.