

ORIGINAL ARTICLE

IMPACT OF PREOPERATIVE DUPLEX MAPPING ON PATENCY OF UPPER ARM ARTERIOVENOUS FISTULA FOR HEMODIALYSIS

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Abstract

Introduction and Aim: It is essential to secure and maintain vascular access for proper dialysis in patients receiving maintenance hemodialysis. The ideal vascular access should be durable, have minimal risk of infection, and require few interventions to maintain patency. We report our experience in preoperative planning for creation of upper arm vascular access for hemodialysis and compare different arm access procedures.

Methods: a single year study that included 455 End Stage Renal Disease (ESRD) patients who underwent an arm vascular access procedure. Preoperative duplex mapping was performed for all patients. Ascending phlebography was done in case of questionable patency of central veins (103 patients). We attempted to first place a simple brachiocephalic AVF at the antecubital fossa. If this was not feasible, we placed a transposed brachio basilic AVF. We performed graft AVF as a last option in case of unsuitable cephalic or basilic veins in the arm. All patients were followed up for at least 12 months after operation. Complications and patency rates were recorded for this period.

Results: 286 patients (62.9%) underwent brachiocephalic AVF, transposed basilic vein and brachio basilic AVF was performed in 122 cases (26.8%) and 47 patients underwent graft AVF.

434 created access (95.4%) were successful with palpable and audible thrill. Accuracy of duplex based decision was measured in reference to intraoperative findings and post-operative results. It was accurate in 334 cases (94.8%). Overall patency rate for all AVF types at the end of the first year was 80.2%. It was 84.6% for the brachiocephalic AVF, 79.5% for the transposed brachio basilic AVF and 55.3% for the graft AVF. In the follow up period, Infection was the most frequently seen complication (13.2%). 17 created access (3.7%) were thrombosed. In the current series, graft AVF was most prone to infection (27.7%) and thrombosis (10.6%) in comparison to other access procedures.

Conclusion: our findings support that Preoperative duplex planning should be performed for all patients. Brachiocephalic fistulas should still be the access of first choice in the upper arm for its best patency rates and fewest complications. However brachio basilic fistulas should be considered second because compared with grafts, they offer similar patency with less risk of thrombosis, and infection.

Keywords: Vascular access, Hemodialysis, Duplex.

INTRODUCTION

End-stage renal disease (ESRD) is a significant public health problem. Increasing prevalence of patients requiring hemodialysis has resulted in dialysis access procedure becoming one of the most common operations performed by vascular surgeons.⁽¹⁾ Egypt is one of the 15 countries with the largest dialysis patient populations.⁽²⁾

It is essential to secure and maintain vascular access for proper dialysis in patients receiving maintenance hemodialysis. The ideal vascular access should be durable, have minimal risk of infection, and require few interventions to maintain patency. The National Kidney Foundation Dialysis Outcome Quality Initiative (NKF K/DOQI) guidelines published in 1997 encouraged the use of autogenous arteriovenous fistulas (AVFs), emphasizing that they could maintain long life spans with minimal complications and interventions. According to the guideline, autogenous AVFs have been preferred over prosthetic arteriovenous grafts (AVGs).^(3,4)

Distal, direct AVFs are recommended first, with the more proximal and complex autogenous access procedures advised where appropriate, based on history/physical examination and a variety of imaging modalities. Ultrasound mapping of the vessels is widely recommended before access surgery, aiding in both venous and arterial evaluation. Ultrasound examination by the operating surgeon offers important information and insight into access opportunities, particularly in complex patients. Specifically, it allows the surgeon to confirm and map the vascular anatomy along with the planned operation.^(5,6)

In the upper arm, there are usually two autogenous arteriovenous fistula options available, including brachiocephalic arteriovenous fistula (BCAVF) and brachio basilic arteriovenous fistula (BBAVF). Unlike other veins in the arm, the basilic vein has the advantage that, being a deep vein, it is protected from damage caused by previous venepuncture and is often of good caliber. However, the basilic vein must be mobilized and superficialized during fistula formation, thus increasing the complexity of the procedure as well as complication rates.⁽⁷⁾

On the other hand, the cephalic vein is superficial in most patients, which is easily damaged with previous venepunctures, and surgical technique to create BCAVF is relatively simple. However, there is no consensus on which of these types of AVF is to be preferred. Although autogenous BBAVF have been extensively utilized, there has been significant disparity in published patency rates.^(1,8-10)

Based on published data, the most recent Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines recommend that the order of preference for AVF placement is the radiocephalic AVF followed by the BCAVF and, if either of these is not available, then

BBAVF should be fashioned.⁽¹¹⁾ It is widely accepted because of better patency rates and fewer infection rates compared with prosthetic grafts. However, there is no evidence based on prospective randomized trials to support this recommendation.⁽¹²⁾

If the cephalic or basilic veins in the upper arm are not available, an arteriovenous prosthetic graft should be attempted. However, prosthetic arteriovenous grafts are associated with decreased patency rates and higher complication rates in addition to higher yearly costs compared to autologous AVFs.⁽¹³⁻¹⁵⁾

We aim to report our experience in preoperative planning for creation of arm vascular access for hemodialysis and to compare all three forms of arm access procedures.

PATIENTS AND METHODS

We evaluated patients with ESRD who were candidates for hemodialysis and creation of arm vascular access was indicated during one year period. The current series included 455 patients (mean age= 48.19 years).

Patient demographics are demonstrated in table 1 showing gender and important medical comorbidities that could affect the procedure or the outcome.

Table 1. Patient demographics.

Sex	Male= 257 (56.5%) Female= 198 (43.5%)
Diabetes Mellitus	33
Ischemic Heart Disease	11

Preoperative assessment: All patients underwent clinical examination that consisted of inspection and palpation of the vessels of the arm, and measurement of brachial artery blood pressure on both sides. Arterial patency was assessed by arterial pulse examination. Venous evaluation consisted of examination of the veins of the arm and cubital fossa with a tourniquet in place.

Duplex mapping and based decision were made for all cases. Inconclusive duplex scans, proximal venous occlusion or the history of central venous line fixation, all indicated the performance of ascending phlebography (103 patients, 22.6%).

Preoperative duplex mapping: Duplex scanning of the arteries and superficial veins was performed at the vascular surgery department using Philips Envisor (Philips Medical Systems, Bothell, Wash) with a 12-3 MHz linear array probe. Exams were made with patient seated and arm resting on a pillow.

The anteroposterior internal diameter and flow characteristics of the brachial artery were recorded. Exam

protocol included the forearm arteries to exclude distal arterial affection.

Ultrasound venous mapping is performed with a tourniquet placed around the upper arm, and all veins seen were evaluated for their anatomical course, internal diameter, their depths and evidence of scarring and thrombosis. The diameters of the cephalic and basilic veins were measured using B-mode technique. The axillary and subclavian veins were examined for indirect assessment of central veins. Evidence of stenosis or occlusion in the non visualised brachiocephalic vein included diminished respiratory phasicity and transmitted cardiac pulsatility.

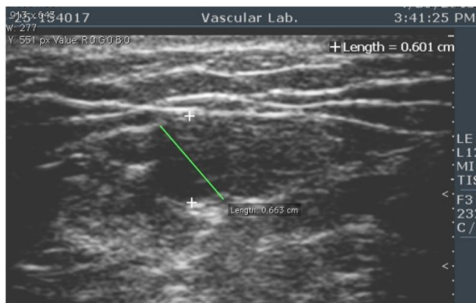


Fig 1. Shows measurement of the diameter of the basilic vein in the cubital fossa.

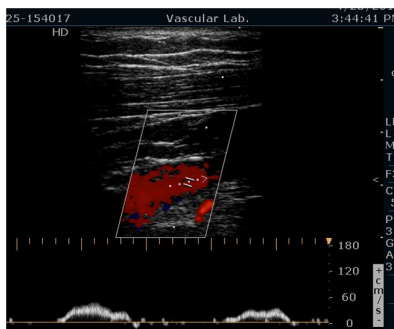


Fig 2. Demonstrates the respirophasic venous flow in the subclavian vein indicating patent central veins.

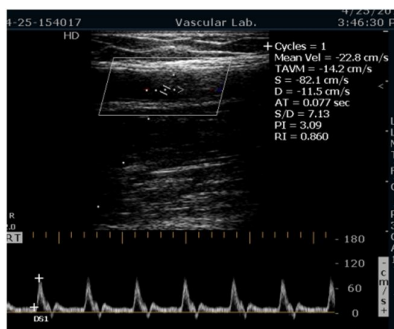


Fig 3. Demonstrates the Duplex arterial mapping. Brachial artery at the cubital fossa shows normal tripahsic waveform.

Duplex findings were demonstrated in a detailed map indicating the possible options for vascular access creation. Fig. 4 shows the duplex map used in the current study. Preference was given to the nondominant arm over the dominant arm.

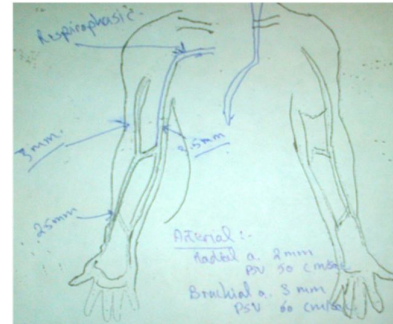


Fig 4. Preoperative Duplex Mapping used to assess the superficial veins of the arm. Diameters were recorded at different levels. Arterial flow and diameter were assessed. Presence of central venous lines were demonstrated.

Exclusion criteria included: previous BBAVF or BCAVF, less than two mm of diameter of the brachial artery at the elbow, absence of radial or ulnar artery pulses and less than two mm of diameter of the basilic or cephalic veins in any location in the upper arm. We excluded as well the forearm AVF as we meant to compare the different types of vascular access in the same region which is the upper arm. Besides, several studies confirmed its best patency rates and priority when planning for a hemodialysis vascular access.^(3,4,6)

Decision protocol: In our practice, we attempted first a simple brachiocephalic fistula at the antecubital fossa. If this was not feasible, we placed a transposed BBAVF.

During the study period, BC AVF was performed in 286 patients. BB AVF after transposition of the basilic vein was performed in 122 cases. The study included as well 47 patients who were candidates for graft AVF.

Surgical procedure: BC AVFs were created by making a transverse incision just proximal to the elbow. The cephalic vein was dissected free and transected at the level of elbow. Subsequently, an end to side anastomosis was performed.

Transposed BB AVFs were constructed by making a longitudinal incision at the medial side of the upper arm to dissect the basilic vein. Care was taken not to injure the medial cutaneous nerve of the arm during vein dissection. All branches of the vein were isolated, ligated, and divided. The basilic vein was mobilized up to its junction with the brachial vein and was transected at the

level of elbow. Then, without clamping, the vein was gently dilated with a heparinized saline injection. An anterolateral subdermal tunnel was created using a long clamp on the anterior aspect of the arm. Subsequently, the basilic vein was pulled through the tunnel and an end-to-side vein-to artery anastomosis was performed with a running 6-0 polypropylene suture with a limited arteriotomy of six to seven mm. Additional care was taken to secure hemostasis at the end of the procedure.

Technical success was defined as the presence of a palpable thrill on the fistula at completion of procedure and 24 hours postoperatively. AVF were allowed to mature for a minimum of four weeks. Maturation was defined as the time until the primary fistula was suitable to allow successful cannulation. Cannulation of the fistula was allowed after maturation, approximately four to six weeks.

Brachioaxillary access grafts required exposure of the axillary vein and brachial artery via small incisions in the axilla and antecubital fossa, respectively. Six-millimeter expanded polytetrafluoroethylene graft was tunneled subcutaneously in a straight configuration, and anastomosed to the vein and artery end to side by using 6-0 Prolene.

Follow-up: All patients were followed up or at least 12 months after operation. Complications and patency rate were recorded for this period.

RESULTS

Among the 455 performed procedures in the current series, 286 patients (62.9%) underwent brachiocephalic AVF, transposed basilic vein and Brachio basilic AVF was performed in 122 cases (26.8%) and 47 patients underwent graft AVF.

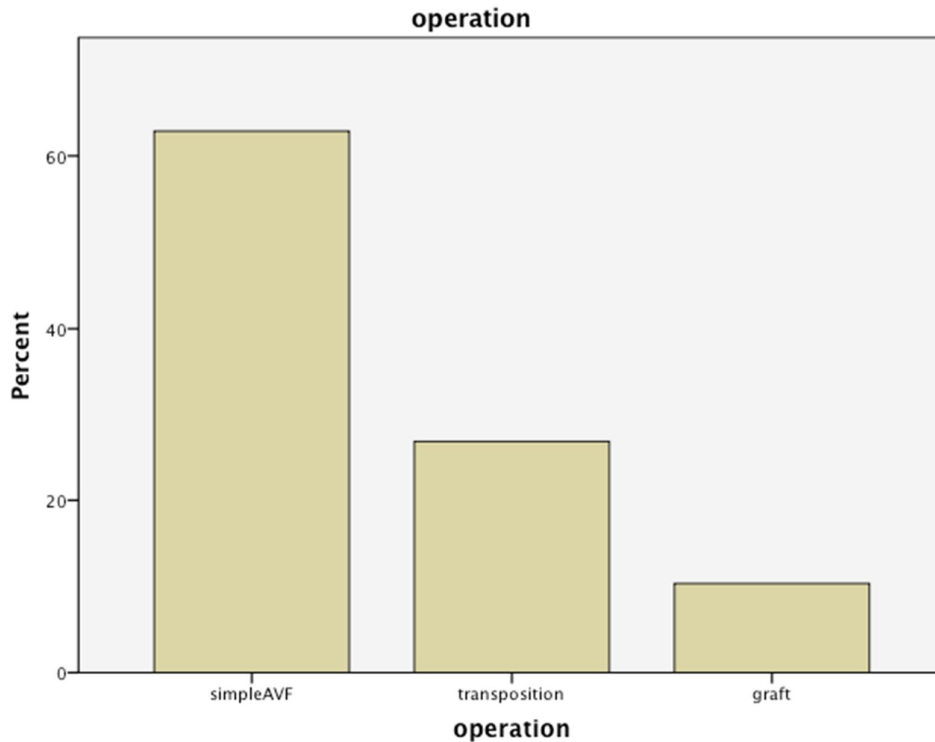


Fig 5. Vascular access procedures performed in the current study.

Following completion of the procedures, 434 created access (95.4%) were successful with palpable and audible thrill. Table 2 demonstrates accuracy of different diagnostic modalities used to plan for the vascular access.

Accuracy was measured in reference to intraoperative findings and post-operative results. Duplex based decision was accurate in 334 cases out of 352 patients (94.8%).

	Successful	Non- Successful	Total
Duplex based decision	334 (94.8%)	18	352
Ascending phlebography	100 (97%)	3	103

Overall patency rate for all AVF types at the end of the first year was 80.2%. it was 84.6% for the brachiocephalic AVF, 79.5% for the transposed brachiocephalic AVF and 55.3% for the graft AVF. Table. 3 shows one year patency rates in AVF performed after duplex and ascending phlebography.

	Patent	Non-patent
Duplex based decision	275 (78%)	77
Ascending phlebography	82 (79.6%)	21

In the follow up period, Infection was the most frequent seen complication (13.2%). 17 created access (3.7%) were thrombosed. Table 4 demonstrates the complications seen during the follow up period.

	Frequency	Percent
Thrombosis	17	3.7%
Infection	60	13.2%
Non maturation	2	0.4%
Aneurysm	10	2.2%
Steal	4	0.9%
Venous hypertension	2	0.4%

In the current series, graft AVF was most prone to infection (27.7%) and thrombosis (10.6%) in comparison to other access procedures. Table 5 Shows the distribution of complications for each performed procedure.

	Infection	Thrombosis	Aneurysm	Non-maturation	Steal	Venous HTN
Brachiocephalic	32 (11.2%)	5 (1.7%)	5 (1.7%)	2 (0.7%)	2 (0.7%)	2 (0.7%)
BrachioBasilic Transposition	15 (12.3%)	7 (5.7%)	5 (4.1%)	0	0	0
Graft	13 (27.7%)	5 (10.6%)	0	0	2 (4.3%)	0

DISCUSSION

In the current series we report our experience evaluating 455 patients with ESRD who were candidates for hemodialysis and creation of arm vascular access was mandated.

Because of the development of the medical technology, the mean of age patients depending on dialysis has increased and the life span of patients with renal failure has also increased, making the preservation of vessels for vascular access more important.⁽⁴⁾

Each patient underwent preoperative vein mapping in our vascular lab. If a suitable cephalic vein is not identified, we then evaluate the basilic and axillary veins. We excluded veins of less than 2 mm in diameter. Seeger et al looked at the cephalic vein in the upper arm, but not the forearm. They used a size 2.5 mm as usable for bypass.⁽¹⁶⁾ Tordoir used a supine position with a stand-off device on the probe.⁽¹⁷⁾ No tourniquet was mentioned

and the largest diameter was used. Silva et al. used tourniquets and 2-mm size criteria.⁽¹⁸⁾ The University of Washington uses a tourniquet, extra pillows, and a blanket for 10 to 15 minutes. The head is elevated with the arm dependant, a pillow is placed under the forearm, and the arm is slightly flexed. The largest transverse diameter is measured and a size of 2 mm is considered adequate for bypass.⁽¹⁹⁾

In the current series, preoperative duplex mapping was made for all patients. It was the sole imaging tool in 352 patients (77.3%). Ascending phlebography was necessary in 103 cases in whom duplex images were inconclusive or indicated central venous disease. Anyhow, Duplex rescans for those cases were mandatory seeking for vessel diameter, vascular wall condition, assess arterial hemodynamics or mark the site of the basilic vein on the skin to limit skin incisions.

Duplex was accurate as regards the decision making in 334 cases (94.8%) in reference to the intraoperative

findings and the post-operative results. Primary failure rate was 5.2%, as duplex was wrong in 18 cases. Those patients underwent ascending phlebography that revealed occlusive disease in the central veins where duplex imaging was very limited. Mihmanli et al. reported a significantly lower failure rate among 72 patients randomised to arteriovenous fistula creation directed by duplex sonography in comparison with their counterparts whose operations were based on clinical examination alone.⁽²⁰⁾ The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) recommends that duplex sonography of the upper limb arteries and veins be performed in conjunction with clinical examination in all patients for whom an arteriovenous fistula is being considered.⁽²¹⁾ In the current study, we cannot compare duplex mapping to the ascending phlebography as they were complementary rather than competitive.

Autogenous BB AVF perform similarly to BC AVF and both outperform AVG. These data support the conclusion that patients who are not candidates for simple BC AVF but who are candidates for BB AVF, based on anatomical criteria, should always be offered the latter procedure. Upper arm AVG should be utilized only in those patients in whom BB AVF construction is not possible.⁽¹⁾ Our results confirmed this notion where best patency rates come with the BC AVF 84.6% then with transposed BB AVF 79.5% and least with AVG 55.3%.

Koksoy et al. reported similar results of 1-year patency rate of 87% for BC group and 86% for the BB group. They found no significant difference in patency rates between the two AVF types.⁽¹²⁾ In another study reported by Fitzgerald et al, there were no significant differences in outcomes between two AVFs and they perform equally in upper arm AVF.⁽²²⁾ Also, higher one year patency rates for BCAVF than BBAVF were reported by other studies, 79% and 72%, respectively.^(8,23,24) In another retrospective analysis of 190 patients with upper arm AVF, Woo et al concluded that autogenous BCAVF and transposed BBAVF have similar patency rates. However, they reported higher patency rates for BBAVF than BCAVF. The primary and secondary patency rates were 52% and 62% at five years for BBAVF and 40% and 46% at five years for BCAVF, respectively.⁽¹⁾

Regarding AVG, similar results reported by Modarai et al. who found that the one year patency rate was 50%.⁽²⁵⁾ while higher patency rates recorded by several studies who reported 63%-69% one year patency rate.^(7,26-28)

There are several theoretical advantages of selection the basilic vein over the cephalic vein when considering AVF creation. Unlike other veins in the arm, the basilic vein is naturally deep, protected from damage caused by previous venepuncture and has a larger diameter. On the other hand, these anatomical advantages lead to a more demanding, complete surgical dissection and prolong

surgery in order to manage these technical factors; the procedure is often performed under general anesthesia. On the other hand, local anesthesia used to create BC AVF has known advantages in terms of safety, length of hospitalization and lower cost. Therefore less invasive BCAVF remain the procedure of choice when both veins are available.⁽¹²⁾

Complications such as thrombosis and infection were significantly less frequent in patients with BC AVF and BB AVFs than in those with AVGs.^(4,28,29) Meanwhile, BB AVF is believed to be subject to many technical complications, such as wound complications, due to the long incision and vein kinking or twisting during tunneling. We can, however, minimize those problems with meticulous surgical technique.⁽⁴⁾ In the current series, graft AVF was most prone to infection (27.7%) and thrombosis (10.6%) in comparison to autogenous access procedures. In contrary, other study stated that the most common complications were thrombosis (27%), graft infection (21%).⁽²⁶⁾ Weale et al. reported 15.7% for thrombosis and 6.2% for infection.⁽²⁸⁾

In conclusion, our findings support that preoperative duplex planning should be performed for all patients. It could be used as the sole preoperative imaging tool in most of cases or complementry to the ascending phlebography in case of questionable patency of central veins.

Our results concluded that brachiocephalic fistulas should still be the access of first choice in the upper arm for its best patency rates and fewest complications. However brachio-basilic fistulas should be considered the second choice because compared with grafts, they offer similar patency with less risk of thrombosis, and infection. In the mean time we encourage dialysis programs to offer transposed brachio-basilic fistulas to patients prior to placing an upper arm graft.

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