Original Research Article

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Prospective long-term study of outcomes of 100 arteriovenous fistulas in patient with chronic renal failure

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ABSTRACT

Background: This study describes the experience of arteriovenous fistula (AVF) creation as vascular access for haemodialysis.

Methods: This study has been carried out in our hospital from January 2004 to December 2016. A total of 154 AVFs were created in 100 patients. Maximum follow-up was 2 years, and minimum was 6 months.

Results: In this study of 100 cases of AVFs, primary patency rates by Kaplan Meier analysis showed 78.81% patency of fistulas at the end of 1 year and patency dropped to 14.81% at the end of 5 years. The primary failure rate was 21.2%. Basilic vein was used in 26.35% cases, cephalic vein in 63.5%, and antecubital vein in 9.75% cases. On table, bruit was present in 134 (90.9%) and thrill in 126 (89.3%) cases. During dialysis, flow rate >250ml/min was obtained in 40(29.9%) cases. In complications, 2 (0.4%) patients developed distal oedema.

Conclusions: Presence of on table thrill and bruit are indicators of successful AVF. If vein diameter is <2mm, chances of AVF failure are high. Flow rates in patients with vein diam. More than 2mm was significantly higher as compared with patients with vein diam. Less than 2mm (P< 0.001). Flow rates are higher in non-diabetic patients as compared to diabetic patients (P <0.001). Average blood urea and serum creatinine values are significantly lesser in patients undergoing dialysis through successful fistulas as compared to patients with failed fistulas. Correspondingly, incidence of deaths is significantly lesser in patients with successful fistulas. During proximal side-to-side fistula between antecubital/basilic vein and brachial artery, dilating of the first valve toward wrist helps to develop distal veins in the forearm by retrograde flow. This technique avoids requirement of superficialization of basilic vein in the arm.

Keywords: Arteriovenous fistula, Chronic kidney disease, Haemodialysis, Vascular access

INTRODUCTION

The surgical creation of an AV fistula provides a longlasting site through which blood can be removed and returned during hemodialysis. The fistula, which allows the person to be connected to a dialysis machine, must be prepared by a surgeon weeks or months before dialysis is started. When the vein and artery are joined, the vein gradually becomes larger and stronger, creating the fistula that provides vascular access years longer than other types of access and with fewer complications. Sometimes dialysis is only needed temporarily, but some people need it for the rest of their lives or until a kidney is available for a transplant. When kidney failure is diagnosed, time is needed to prepare the patient's body with either an AV fistula or implantable devices that will connect the person to the dialysis machine.¹

This is single-centre, single surgeon observational study comparing pre-operative vein and artery diameters, presence of bruit and thrill on operation table, flow rates, site of the fistula, associated comorbidities for postoperative outcome, and duration of patency by Kaplan-Meier analysis.

METHODS

This observation study was carried out in the institute in patients who underwent surgical AVF creation between January 2014 and December 2016.

Patients were advised surgery for AVF when their serum creatinine level persistenthigh.² HD catheter was inserted only in cases who presented late and required HD before maturation of fistula.

History of diabetes mellitus, anticoagulant therapy for coagulation disorder, cardiovascular disease, heart valve disease or prosthesis, previous dialysis access, previous central venous, or peripheral catheter were noted. Physical exam of the arterial system (peripheral pulses, Allen test, and bilateral upper extremity blood pressure) was performed along with physical exam of the venous system (tourniquet venous palpation with vein mapping, examination for previous central or peripheral venous catheters, etc.).

Dominance of hand was examined, and preference was given to non-dominant hand for creation of vascular access. Pre-operative colour Doppler ultrasound (duplex) of upper limb veins and arteries was done in selected patients to look for size and patency. It was done in patients with inadequate clinical examination findings like in cases with obesity, absent or feeble pulses, multiple previous access surgeries, indwelling dialysis catheter on the same side, and history suggestive of thrombophlebitis. Subclavian vein catheterization was avoided for temporary access in all patients due to the risk of central venous stenosis, which compromises entire ipsilateral arm for vascular access. Arm veins suitable for vascular access placement were preserved, and patients and dialysis staff were instructed not to prick selected arm.

In cases where there was extensive venous thrombosis in a particular limb different limb was selected for fistula. During this period, AVF was created in 135 patients; but, we could follow-up only 100 patients. Follow-up was obtained in collaboration with dialysis unit staff by telephonic calls and personal visits to the patients. The data extracted from hospital records included patient demographics, comorbidities, details of previous access, location and type of AVF, operative details, patency, morbidity, and mortality.

A total of 154 AVFs were placed in 135 patients as 19 patients required repeat procedure due to failure of the previous fistula. Of the 135 patients 39(28.9%) patients have died. Average mean survival in dead patients was 1.59 (standard deviation ± 1.07) years. However, before death they were regularly followed-up on dialysis.

Maximum follow-up was 2 years, and minimum followup was 6 months.

Surgical technique

All patients were admitted on the day of surgery. All cases were done under local anaesthesia using 10cc 2% Xylocaine by single surgeon under loupe magnification using microvascular instruments. "S" shape 2.5-3cm long incision was used. Vein and artery were mobilized adequately. Arteriotomy size in all cases was 6-7mm. In cases wherein, there was extensive atherosclerosis involving the artery best possible segment of exposed artery was selected for anastomosis. Diameter of the vessels were noted using calipre. Anastomosis was done by taking continuous running suture using 7-0 polypropylene or 8-0 ethilon depending upon vessel wall thickness. For distal and mid forearm fistula, end of the cephalic vein to side of radial artery anastomosis was performed (Figure 1).

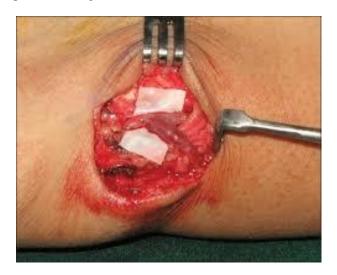


Figure 1: Distal end to side radio-cephalic fistula.

For proximal fistula, we performed side - to-side anastomosis between antecubital or basilic vein and brachial artery (Figure 2).

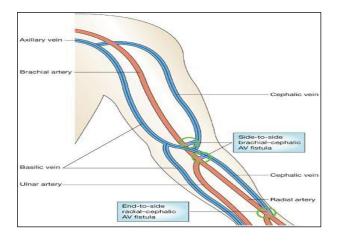


Figure 2: Proximal side-to-side brachiobasilic fistula.

Before anastomosis was completed, we dilated distal vein using venous dilator to break the first valve toward the wrist end to allow retrograde flow into forearm veins (Figure 3, 4). This allows forearms veins to develop which can now be easily assessed for cannulation. This technique avoided requirement of basilic vein transposition in the arm thus avoiding long incisions in arm and reducing morbidity of the procedure. In cases where antecubital vein was used, both cephalic and basilic veins got arterialized and could be cannulated. Skin closure was done with 3-0 ethilon in a single layer. Non-compressive dressing was given. Bruit was heard, and thrill was felt on operation table end of dressing. In cases where bruit and/or thrill was absent, but there was good venous filling, we started anticoagulation with low molecular weight heparin subcutaneously for 3-5 days, (doses according to creatinine clearance), along with tablet aspirin 75mg once a day for 3-5 days.



Figure 3: Well developed forearm veins in proximal AVF.

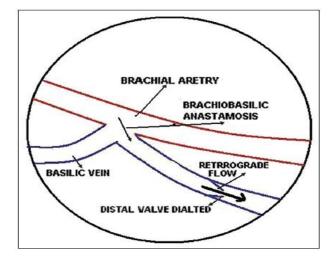


Figure 4: Diagrammatic representation of retrograde flow across dilated valve.

Patient was discharged on the same day or next day. Relevant instructions about care of operated side arm were given to the patients and their relatives. They were told to avoid arm vein blood collection on the operated side, avoid blood pressure cuffs, not to use tight clothing or jewellery, and avoid the prolong pressure on operated arm. Written instructions about how to feel for the thrill were given, and patients were asked to report any coldness, numbness, ulcers, discoloration at fingertips. Handball exercises were taught to patients before discharge.

Fistula maturation and its cannulation for use of dialysis were decided by nephrologists based on visible enlarged vein and well felt thrill, which required 4-6 weeks after construction. Author considered 250ml/min as a flow rate obtained on HD machine during HD, which was sustained for a minimum of 3 h without recirculation as acceptable flow during HD.

Author followed the National Kidney Foundation/Disease Outcome Quality Initiative (NKF-K/DOQI) Vascular Access Clinical Practice Guidelines 2000.³ However, few guidelines could not be followed, for example, early reference, timing of access placement (1-4 months before anticipated HD), Doppler ultrasound in all cases and early intervention in failing fistulas. Above limitations were due to poor patient compliance and affordability in Indian scenario. In none of our patients and interventional or salvage procedure was done. Hence, our patency statistics is of 100% primary patency rates.

The data were analysed using IBM SPSS (statistical package for social sciences) version 20. Student's t-test was used to find the differences. Paired t-test is not appropriate in our series as it is for pre- and post-comparison. Chi-square test was used to look at the association.

RESULTS

In the present series of 154 fistulas (baseline characteristics, 47(30.51%) were proximal fistulas, 103 (66.88%) were distal fistulas, and 4 (2.6%) were mid forearm fistulas (Table 1).

Table 1: Baseline characteristics.

Senario	Number
Number of AVFs created	154
Number of patients	135
Number of successful AVFs	121
Age	54.58(+/- 14.092)
Gender	
Male	97(62.98%)
Female	58(37.02%)
Diabetes	75 (48.76%)
Atherosclerosis	6(4.1%)
Coagulopathy	1(1.54%)

AVFs: Arteriovenous fistula

Preference was given to non-dominant hand. However- in cases where non-dominant hand was pricked repeatedly or had intracath insitudominant hand was selected. Fortyone fistulas were done on the right side, and 113 were done on the left side. Basilic vein was used in 41cases; cephalic vein was used in 101 cases, and antecubital vein was used in 12 cases. Vein anastomosis was done with radial artery in 107 cases and brachial artery in 47cases. End (vein) to the side (artery) anastomosis was done in 94 cases. Side (vein) to the side (artery) anastomosis was done in 70 cases. Bruit was heard in 140(90.90%) cases and thrill were felt in 134 (87.01%) cases on the operation table. Both bruit and thrill were present in 134 cases (87.01%). During HD, flow rate >250ml/min was obtained in 45 (29.22%) cases (Table 2). It was sufficient to perform successful HD in these patients as it sustained for a period of at least 3 h during 4 h of HD. The flow rate >250 ml/min was not flow across fistula, as measured by radiological or any other means, but actual flow rate obtained on blood pump during HD.

Table 2: Presence of bruit and thrill.

Senario	No. of patients	Failures (%)
Bruit+,thrill +	134	25(16)
Bruit+,thrill-	6	4(63)
Bruit-,thrill+	003	1(33)
Bruit-,thrill-	0	0

SD-Standard Deviation, SEM-Standard error mean

In complications, 1 (1.54%) patients developed distal oedema, 4(6.5%) developed steal phenomenon. One patient developed aneurysm. No patients had operative site infection and major bleeding requiring intervention during the follow-up period.

Logistic regression for success and failure using logistic regression with success and immediate failure as the dependent variables it was found that failure is 5.4 times more among subjects with no bruit heard on operation table (P< 0.001) as compared to those with bruit.

Similarly, failure is 6.7 times more among subjects with no thrill felt on operation table (P< 0.001) as compared to those with thrill. Although risk of failure is more among subjects with art <2mm as compared to subjects with art >2mm, it is not statistically significant (P= 0.114) in the series.

Failure is 5.4 times more among patients with vein <2 mm as compared to those with vein >2mm (P<0.001). Risk of failure was observed to be higher among patients with distal fistula (22.6%) than proximal fistula (1.5%), although not statistically significant (P=0.413).

Of 154 fistulas, 134 patients had both presence of bruit and thrill at end of surgery. The failure rate was 16% (n 25) in such cases at end of 12 weeks. When bruit was present and thrill was absent at the end of the surgery (n=6) the failure rate was 63.6% (n=4). Only 3 patients had

a palpable thrill without an audible bruit. Of these three, one fistula failed (33%).

Flow rates

Patients with vein diam. >2mm had higher flow rates (>250ml/min) as compared with patients with vein diam. <2mm. The difference was found to be statistically significant (P= 0.05).

Diabetes

Flow rates across fistula were found significantly higher in non-diabetic patients (P< 0.001) compared to diabetics.

Biochemistry

The average blood urea and serum creatinine values in patients with successful fistulas were significantly (P< 0.001) lower as compared with failures (Table 3).

Table 3: Blood urea and serum creatinine values.

Biochemistry	Mean	SD	SEM
Blood urea level(mg/dl)			
Successful fistulas	87.67	38.778	2.03
Failed fistulas	112.39	38.888	4.077
Serum creatinine(mg/dl)			
Successful fistulas	6.022	2.0449	0.1067
Failed fistulas	8.608	1.7728	0.1858

Site

In proximal fistulas, bruit was heard and thrill was felt in 95.1% cases on operation table. In distal fistulas, bruit was heard in 88.1% and thrill was felt in 85.5% on operation table. Hence, success rate was more (80.5%) in proximal than in distal (77.4%) fistulas.

This difference was however not statistically significant. Of 47cases of proximal fistulas basilic vein transposition for proximal fistula was done in 1 case only.

In rest of the patient's veins over forearm developed within 6 weeks due to retrograde flow across the anastomosis. Distal oedema developed in 2 (0.4%) patients post-operatively.

Mortality

The incidence of deaths was much higher in cases of primary fistula failure (60.7%) as compared with successful fistulas (30.7%). This value had statistical significance (P < 0.001).

Patency

Patency more than 1 year was found in 121 cases (78.81%) and patency more than 2 years was seen in

83cases (53.63). Patency more than 3 years was seen in 53 cases (34.39%) and patency more than 4 years was

seen in 29 cases (19.05%). Patency of more than 5 years was seen in 23 patients (14.81%) (Table 4).

Conditional probability No. of **Probability of** Time (years) **Failures Dropouts Patency** fistulas patency of patency 154 0 154 1 1 0.7881 1 154 33 121 0.7881 2 114 24 83 0.68051 0.68051 81 2 0.34399 3 26 53 0.64138 29 4 53 21 3 0.55385 0.19052 5 23 29 02 4 0.777780.14818

Table 4: Kaplan-Meier analysis for patency.

DISCUSSION

Successful HD depends on creation and maintenance of adequate vascular access. Due to general population aging, median age at onset of ESRD has been progressively increased over last few decades. More than 50% of people have diabetes as a cause of ESRD and average age is 54.5 years.⁴ In this study of 505 cases, average age of presentation was 54.5 years and 75% patients had diabetes as a cause of ESRD.

Patients who receive dialysis across a functional AVF have lower complication rates and longer duration of event-free patency than patients with catheter access and arteriovenous grafts (AVGs).6-9 Thus, construction of a native AVF on arm or forearm is considered a good practice over prosthetic grafts and central venous catheters. There were no AVGs created in the present series. There is vast data proving that native AVFs are superior to grafts as a form of vascular access for dialysis.6 It has been demonstrated that early referral to nephrologists and good collaboration with microvascular surgeon reduce the need for temporary dialysis access for first dialysis and increase the rate of successful AVF placement.¹⁰ However, central venous catheters are primary method of choice for temporary access in which there is urgent need for HD and no other vascular access is available or has failed.8 However, these devices suffer from several complicating factors as infection, thrombosis, venous stenosis, and damage to proximal vessels.11 Author performed AVF in all the chronic kidney disease patients as first choice of vascular access.

The most common operative procedure was the creation of the distal radio-cephalic fistula, initially described by Brescia et al. in 1966. This operation is still considered to be the gold standard for vascular access for HD and it accounted for 103 (66.88%) of our operative procedures. High radio-cephalic (mid forearm) and brachial-basilic AVFs were reserved for patients with previously failed Brescia-Cimino AVFs or where patent adequate size vessels at wrist level were not available for

anastomosis.¹² The outcomes of the classic Brescia-Cimino operation were accompanied by acceptable rates of morbidity.^{13,14} In this analysis of 103 (66.88.4%) distal fistulas,94 (91.26%) were successful. Two patients developed distal oedema (1.94%) and 7 patients developed steal phenomenon (6.79%). Mortality among cases with radio-cephalic fistulas was 34 (33.01%).

Most large-volume centres report 15-30% primary failure rates for distal radio-cephalic AVF.^{13,14} The reported incidence of primary failure in the medical literature varies from9% to 40% and the results with 21.2% primary failures were comparable.^{15,16} Primary Failure is defined as Absence of well-developed veins accessible for dialysis at 12 weeks after fistula surgery.¹⁶ The NKF/DOQI work Group did not recommend the use of primary failure as an index of quality because it would discourage attempts at AVF construction in patients with complex vascular anatomy.²

American Institute of Ultrasound in Medicine Practice Guideline 2011 states that arterial diameter <2mm and venous diameter <2.5mm were associated with high failure rate. This study also proves that venous diameters <2mm are associated with significantly high failure rates (P< 0.001). However, arterial diameter of <2mm was not found to be significant in our series.

Arteriovenous fistula creation in all (100%) patients with ESRD in our institution far exceeds the target goals of 50% set forward by the NKF/DOQI [3] and the Centres for Medicare and Medicaid Services Fistula First Breakthrough Initiative. ¹⁹ This was being achieved with acceptable rates of morbidity (7.2%), no operative mortality and good primary patency (78%). However, early detection of complications by patient education can help to improve long-term patency rates.

Results of Kazemzadeh et al in 2012, in their case series of 245 patients of primary patency at 6 months, 1, 2, 3, and 4 years for 245 patients were 79.5%, 70%, 65%, 60.5%, and 48%, respectively.²⁰ This was comparable to

our results showing 78.81% patency of fistulas at the end of 1 year. However, in our series patency rates dropped to, 53.63% patency at the end of 2 years, 34.39 patency at the end of 3 years, 19.05 patency at the end of 4 years, 14.81 patency at the end of 5 years. Our primary failure rate was 21.18%.

It is routine practice to transpose basilic vein during proximal brachiobasilic fistulas.²¹ In a series of 70 patients with brachiobasilic fistulas in order to gain easy access to veins.²² Hossny observed that all dialysis nurses were satisfied with the transposed veins, but only 53.3% were satisfied with the elevated veins; the difference was statistically highly significant (P<0.001). concluding that among the various procedures, transposition has a lower complication rate and is favoured by the dialysis staff dealing with such fistulas. In our study, during the creation of proximal fistula by side-to-side anastomosis between antecubital/basilic vein and brachial artery, dilatation of distal vein to dysfunction the first valve towards wrist end helps to develop distal veins in the forearm by retrograde flow avoiding need for transposition of basilic vein thus avoiding the additional extensive procedure transposition. In only one of the patients with proximal fistula superficialization of basilic vein in the arm was needed. Distal oedema was seen only in 2 patients with proximal fistula.

Though the risk of failure was observed to be lower in proximal fistulas in our series, it was not statistically significant. In a study conducted by Sultan et al it was observed that 4 years primary functional patency was better with proximal fistula as compared with distal fistulas.²³

Author have established direct correlation of bruit heard at end of surgery and thrill felt at the end of the surgery with the final outcome of the fistula. In the majority of our cases, we had both present at the end of the surgery (134 out of 154). In cases where both were absent the failure rate was as high as 57%. Since the failure is defined as the absence of visible veins suitable for cannulation at the end of 12 weeks after surgery, author have to wait for veins to develop until at least 12 weeks. In cases where either bruit or thrill or both were absent at the end of surgery, author started patient on anticoagulative measures as described earlier along with handball exercises. No surgical intervention was done in any of the cases with absent bruit and/or thrill. In India, because of poor socioeconomic status, fistula salvage by early detection of failing fistula and intervention by exploration, embolectomy, or radiological intervention like percutaneous angioplasty for venous outflow stenosis is not cost-effective.3 In this study, no salvage or secondary procedures were done and hence all our statistics reflect primary failures. Author prefer to perform new fistula in cases where previous has failed or not.

CONCLUSION

Authors found that vein diameter <2mm showed very high failure rate (P<0.001). Hence, we recommend either using proximal site or use of the alternative method of access placement such as peritoneal dialysis/permacaths in such patients. Thrill felt on the operation table has a direct relation with success of fistula operation (P<0.001). Similarly, presence of on table bruit was found to be statistically significant in correlation with success of fistula surgery (P<0.001).

Flow rates in patients with vein diameter >2mm were significantly higher as compared with patients with vein diameter <2mm (P<0.001). Flow rates are higher in non-diabetic patients as compared with diabetic patients (P<0.001). Average blood urea and serum creatinine values are significantly lesser in patients undergoing dialysis through successful fistulas as compared with patients with failed fistulas. Correspondingly, incidence of deaths is significantly lesser in patients with successful fistulas (P<0.001). During the creation of proximal fistula by side-to-side anastomosis between antecubital/basilic vein and brachial artery, dilatation of distal vein to dysfunction the first valve towards wrist helps to develop distal veins in the forearm by retrograde flow avoiding need for basilic vein transposition.

Primary patency rates by Kaplan-Meier analysis shows 78.81% patency of fistulas at the end of 1 year, 53.63 patency at the end of 2 years, 34.39 patency at the end of 3 years, 19.05% patency at the end of 4 years, 14.81 patency at the end of 5 years. The presence of Bruit and thrill on the operation table at the end of the surgery are the key indicators of successful fistula. This has not been reported in the literature so far to the best of our knowledge.

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Institutional Ethics Committee

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