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Original Article

Preoperative Factors Predicting the Outcomes of Arteriovenous Fistula Surgery

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ABSTRACT

Purpose: The aim is to study the preoperative factors predicting the outcome of arteriovenous fistulas (AVF) in chronic kidney disease (CKD) patients. Successful AVF formation is vital to the success of hemodialysis treatment. The factors leading to failure of AVF maturation are still ill defined and there is a limited ability to predict surgical vascular outcomes. In part, this is due to the heterogeneity of end-stage renal disease populations. **Methods:** A prospective observational study was under taken on CKD patients requiring vascular access surgery for a period of 2 years were from June 2023 to May 2025. Informed consent was obtained. Demographic, clinical factors, comorbidities including age, gender, site, laterality, smoking, diabetes, hypertension, coronary artery disease and peripheral vascular disease, vessel caliber, type of anastomosis, flow across vein, and anastomosis were noted. The patient's vessel status recorded preoperatively by a Doppler ultrasound.
Postoperative assessment of AVF was performed with Doppler 4 weeks after surgery. Data were analyzed to assess the risk factors predicting AVF outcomes. **Results:** A total of 330 cases of AV fistula were enrolled in the study. Of these 330 cases, they were categorized and evaluated separately according to the site of fistula creation. 180 underwent radio-cephalic fistulas, 100 brachio-cephalic and 50 had brachio-basilic fistulas. All the fistulas were separately categorized and evaluated for the factors predicting their outcome. **Conclusions:** In this study, the outflow vein diameter, arterial diameter and flow rate in the vein and across the anastomosis were the predominant factor determining the success of the proximal and distal arm fistulas.

Keywords: *Brachio basilic arterio-venous fistula, brachio cephalic arterio-venous fistula, flow velocities, radio cephalic arterio-venous fistula, vein diameters*

INTRODUCTION

Autologous arteriovenous fistula (AVF) is the preferred mode of vascular access for maintenance haemodialysis (HD) in patients with end-stage renal disease (ESRD) because of their good long-term patency and low complication rate. Brescia cimino fistulas are currently accepted as the best mode of vascular access for HD.[1] Native AVF has the best long-term primary patency rate and requires the fewest interventions of any type of access.[2,3] In an order of preference as given in the Kidney Disease Outcomes Quality Initiative guidelines, the radiocephalic fistula is the vascular access of preference followed by the brachiocephalic fistula, brachial-basilic fistula with or without transposition and arteriovenous graft (saphenous/synthetic).[4] The aim of this study is to identify the factors predicting the outcome of AVFs in ESRD patients.

MATERIALS AND METHODS

The aim of this study is to identify the factors predicting the outcome of AVFs in ESRD patients. This is a prospective observational study done on patients who underwent primary AV fistula surgery in this hospital from June 2023 to May

2025. A total of 330 patients were enrolled in this study. Institute Ethical committee approval was taken.

Inclusion criteria
All the cases who were candidates for AVF surgery in our hospital from June 2023 to May 2025.

Exclusion criteria
1. Cases of AVFs who needed autologous grafts and synthetic grafts
2. Patients undergoing redo-surgery for failed fistulas at the same site
3. Patients who had a second fistula during the study period were not enrolled in the study to eliminate bias.

The patients who satisfied the above criteria were included in the study. Patients underwent detailed history taking. Clinical examination for the native AV fistula creation was done. Patients falling under the inclusion criteria were informed about the study and requirement of regular follow-up for the completion of study. Informed consent was obtained.

Various parameters were evaluated influencing the patency of vascular access in an AV fistula. Demographic and clinical factors taken into consideration were age, gender, site, laterality, vessel caliber, type of anastomosis, flow across vein and anastomosis. Patient factors such as smoking and comorbidities such as diabetes, hypertension, coronary artery disease, and peripheral vascular disease were also considered as these have adverse effect on vessel health. The patients vessel status recorded pre-operatively by a Doppler ultrasound to note any stenosis/thrombus in the vessel. Post-operative follow-up was conducted by palpating the thrill, bruit and the presence of flow across vein and across anastomosis by Doppler ultrasound. A successful fistula is defined as one which should be mature, ready for cannulation, and able to deliver the prescribed blood flow throughout the dialysis procedure. Primary failure is defined as the loss of patency before cannulation. Informed written consent was obtained all patients.

Statistical Analysis
Statistical analysis was performed using SPSS software version 25 (IBM Corp., 2017 released, Armonk, NY, USA). After compiling all the data, statistical analysis was performed to evaluate the outcomes of AV fistula. Mann–Whitney U test or independent t-test was used for analysis depending on distribution of variables. Chi-Square test will be used for comparing categorical variables. Value of $P < 0.05$ was considered statistically significant.

RESULTS
A total of 330 cases of AV fistula were enrolled in the study. Of these total 330 AV fistulas created 180 were enrolled for radio-cephalic fistulas, 100 were enrolled for brachio-cephalic fistulas. Fifty were enrolled for brachio-basilic fistulas. All the fistulas were separately categorized and evaluated for the factors predicting their outcome.

Radiochalic arteriovenous fistula
Out of 180 cases 137 were male and 43 were female. 113 (82.5%) cases of 137 male patients had a successful outcome with 24 cases failed fistulae (17.5%). 35 cases(81%) out of 43 had successful outcome in females with 8 cases failed fistulae (19%). The male: female ratio was 3.19:1. The Overall success rate was 82%. The mean age of male was 50.72 ± 12.62 and mean age of female was 49.32 ± 12.97 [Table 1].

Brachiocephalic arteriovenous fistula
Out of 100 cases, 57 were male and 43 were female. 50 (87.7%) cases of 57 male patients had a successful outcome with 7 cases failed fistulae (12.3%). 34 cases(79%) out of 43 had successful outcome in females with 9 cases failed fistulae (21%). The male: female ratio was 1.32:1. The overall success rate was 84%. The mean age of male was 52.7 ± 13.04 and mean age of female was 49.50 ± 14.19 [Table 1].

Brachiobasilic arteriovenous fistula
Out of 50 cases, 37 were male and 13 were female. 32 (86.4%) cases of 37 male patients had a successful outcome with 5 cases failed fistulae (13.6%). 10 cases (76.9%) out of 13 had successful outcome in females with 3 cases failed fistulae (23.1%). The male: female ratio was 2.84:1. The overall success rate was 84%. The mean age of male was 51.48 ± 10.81 and mean age of female was 50.76 ± 12.51 [Table 1].

In the present study, on 180 RC AVF patients failure was more with cephalic vein diameter <2 mm. In 100 BC AVF patients failure was higher with cephalic vein diameters <3 mm. Basilic vein diameter has no significant role on outcome in our study. There is no significant difference in failure rates of BC and BB AVF. In our study, radial artery diameter of <2 mm had more failure rates. Brachial artery diameter with <3 mm had more failure rates for both BC and BB AV fistulas [Table 2]. We have not dilated any vein prior to anastomosis.

In the present study, it showed that blood flow at more than 200 ml/min in cephalic vein for both RC and BC AVF (P =

0.0085 and P = 0.0128) and flow across anastomosis >300 ml/min had more successful outcome (P = 0.00036 and P = 0.0116). Flow of >300 ml/min in basilic vein (P = 0.00682) and >300 ml/min across anastomosis (P = 0.01090) had more successful outcome [Table 3].

Table 1: Distribution of patients according to demographic parameters with success and failure in all arteriovenous

Parameter studied	RC AVF					BC AVF					BB AVF			
	T	S	F	*P*/%		T	S	F	P/%		T	S	F	*P*/%
Male	137	113	24	82.5		57	50	7	87.7		37	32	5	86.4
Female	43	35	8	81		43	34	9	79		13	10	3	76.9
Total	180	137	33	76		100	84	16	84		50	42	8	84
HTN	154	124	30	0.14		90	76	14	0.76		42	36	6	0.72
Non-HTN	26	24	2			10	8	2			8	6	2	
Total	180	148	32			100	84	16			50	42	8	
DM	65	45	20	0.00061		39	29	10	0.035		16	10	6	0.0032
Non-DM	115	103	12			61	55	6			34	32	2	
Total	180	148	32			100	84	16			50	42	8	

T: Total cases, S: Success, F: Failure, NA: Not applied, AVF: Arteriovenous fistula, HTN: Hypertension, DM: Diabetes mellitus, BC: Brachiocephalic, BB: Brachiobasilic, RC: Radiocephalic

Table 2: Distribution of patients according to artery and vein diameter with success and failure in all arteriovenous fistula

	RC AVF					BC AVF					BB AVF			
	T	S	F	*P*		T	S	F	*P*		T	S	F	*P*
Arterial diameter														
<2	38	22	16	0.00002		NA	NA	NA	0.332		NA	NA	NA	0.04448
2.1-3	124	108	16			20	15	5			6	3	3	
3.1-4	18	18	0			34	30	4			26	22	4	
4.1-5	NA	NA	NA			36	29	7			18	17	1	
>5	NA	NA	NA			10	10	0			NA	NA	NA	
Total	180	148	32			100	84	16			50	42	8	
Venous diameter														
<2	73	51	22	0.00032		18	12	6	0.00002		NA	NA	NA	0.76249
2.1-3	86	76	10			40	33	7			15	12	3	
3.1-4	21	21	0			28	25	3			26	22	4	
4.1-5	NA	NA	NA			14	14	0			9	8	1	
Total	180	148	32			100	84	16			50	42	8	

T: Total cases, S: Success, F: Failure, NA: Not applied, AVF: Arteriovenous fistula, BC: Brachiocephalic, BB: Brachiobasilic, RC: Radiocephalic

Table 3: Distribution of patients according to flow rate across anastomosis and flow rate across vein on post-operative day-1 with success and failure in arteriovenous fistula

	RC AVF					BC AVF					BB AVF			
	T	S	F	*P*		T	S	F	*P*		T	S	F	*P*
Flow at anastomosis														
No flow	2	0	2	0.00036		NA	NA	NA	0.0116		2	0	2	0.01090
100-200	22	14	8			4	2	2			2	2	0	
201-300	122	102	20			28	20	8			10	7	3	
301-400	34	32	2			44	40	4			21	19	2	
>400						24	22	2			15	14	1	
Total	180	148	32			100	84	16			50	42	8	
Flow at vein														
No flow	2	0	2	0.0085		NA	NA	NA	0.0128		2	0	2	0.00682

100-200	160	130	30			4	2	2			12	9	3	
201-300	18	18	0			50	39	11			34	31	3	
301-400	NA	NA	NA			42	39	3			2	2	0	
>400	NA	NA	NA			4	4	0			NA	NA	NA	
Total	180	148	32			100	84	16			50	42	8	

T: Total cases, S: Success, F: Failure, NA: Not applied, AVF: Arteriovenous fistula, BC: Brachiocephalic, BB: Brachiobasilic, RC: Radiocephalic

Table 4: Study of various parameters influencing arteriovenous fistula outcomes in the present study with other studies

Parameter	Studies correlation	Studies no correlation	Present study
Age	Nil	Lin et al.[17]	No correlation
Sex (%)	Miller et al.[18] (68 vs. 50)	Caplin et al.[5] (28 vs. 23)	No correlation
Diabetes	Smith et al.[8]	Fernström et al.[19]	Correlation (P<0.05)
HTN	Wong et al.[15]	Patel et al.[9]	No correlation
Cephalic vein diameter (mm)	Brimble et al.[10] (>2) Malovrh[13] (1.6)	Nil	Correlation (P<0.05)
Radial artery diameter (mm)	Wong et al.[15] (1.6) Malovrh[13] (1.8)	Nil	Correlation (P<0.05)
Brachial artery diameter (mm)	Wilmink et al.[14] (>3)	Nil	Correlation (P<0.05)
Flow across vein and anastomosis on POD-1	Anderson et al.[20] Wong et al.[15]	Nil	Correlation (P<0.05)

DISCUSSION

The primary factors that determine the resistance to blood flow within a single vessel include vessel diameter (or radius), vessel length, and viscosity of the blood. Of these three factors, the most important quantitatively and physiologically is vessel diameter. Poiseuille's Equation describes that vessel resistance (R) is inversely proportional to the radius to the fourth power (r^4). Current study focused on: demographic factors, comorbidities, arterial diameter, venous diameter, and flow rate.

In our study, age and sex had no significant relation to the outcome of AV fistula. Caplin et al. showed that arterial and venous diameters were not significantly different between men and women.[5] Subsequent meta-analysis data suggest that women have similar maturation and 1-year patency rates as men for RCAVFs. Monroy-Cuadros et al. did not find a significant association between sex and the risk of AVF failure, even after adjusting for age, presence of diabetes mellitus, hypertension, history of peripheral vascular disease, smoking history, and type of procedure.[6]

In the present study, diabetes had a significant influence on the outcome of all types of AV fistula ($P < 0.05$). These patients had multiple failures compared to nondiabetics who required multiple fistula creations. According to Manne et al. diabetes did not affect the patency of fistulas.[7] Fernström et al. have shown that diabetes did not influence failure rate, but significantly shortened the mean patency time. Smith et al. had a significant correlation of diabetes to the patency of AVF.[8]

In our study, significance of hypertension could not be assessed as the number of nonhypertensive patients were too small to compare with the hypertensive patients. According to Manne et al. hypertension was a major factor that profoundly affects vascular access patency.[7] According to Patel et al., there was significant correlation of Hypertension to vascular patency.[9]

In the present study, on 180RC AVF patients failure was more with cephalic vein diameter <2 mm and >2 mm had more successful outcome. In 100 BC AVF patients failure was more with cephalic vein diameters <3 mm as compared to >3 mm had a successful outcome. Basilic vein diameter has no significant role on outcome in our study. No much difference is seen in failure rates of BC and BB AVF. Two studies have directly assessed venous diameter and its importance in determining fistula outcome. Brimble performed a retrospective study on 106 patients with cephalic vein diameter was 2.52 and 2.23 mm in successful and failed fistulae, respectively.[10] Mendes analyzed 44 consecutive patients and he concluded that venous diameter of >2.0 mm had higher successful rate.[11] Although a precise threshold for minimal vein diameter in successful fistulae has not been established. Most clinical studies use a cut off value of 2.5 mm for AVF, and 4.0 mm for synthetic grafts as suggested by Silva et al. [12] The ability of a vein to dilate is also an important predictor of a successful fistulae. Malovr found that venous diameter increased by an average of 48% in patients with successful fistulae compared with only 11.8% in fistulae that failed.[13] Wilmink et al. have found that cephalic vein diameter and basilic vein diameter has to be minimum 3 mm for a successful outcome of BC and BB AVF, respectively.[14]

In our study, radial artery diameter of <2.5 mm had failure rates, more if <2 mm for RC AVF. Brachial artery diameter

with <3 mm had more failure rates for both BC and BB AV fistulas. There is limited literature on the influence of arterial diameter and vessel quality on fistula success rate. Wong et al. showed that a luminal diameter of <1.6 mm was associated with early fistula failure.[15] Malovrh reported that a diameter of <1.5 mm was associated a success rate of only 45%.[13] Lemson et al. observed significantly smaller mean preoperative radial artery diameters among patients with failed forearm fistulae compared with successful fistulae (1.9 vs. 2.8 mm).[16] Wilmink et al. in their study found that brachial artery diameter has to be >3 mm for creation of a BC or BB AVF.[14]

In our study it showed that blood flow at >200 ml/min in cephalic vein for both RC and BC AVF and flow across anastomosis >300 ml/min had more successful outcome. In our study, flow of >300 ml/min in basilic vein and >300 ml/min across anastomosis had more successful outcome [Table 4]. Johnson et al. reported that a high intra-operative flow volume defined as 320 mL/min or greater was associated with a lower number of surgical revisions and longer access survival regardless of gender, race or presence of diabetes.[21] Anderson et al. in almost half of the patients in whom flow measurements were made.[20] However, most of these vessels recovered fully by the following day and in the majority of the cases the flow greatly increased compared with intraoperative values. Consequently, the blood flow velocity measured the day after the operation correlated better with early failure of the fistula than intraoperative volume blood flow. In a study comparing end-to-side to side-to-side fistulae, Wedgwood et al. found that successful fistulae have a significantly higher intraoperative blood flow than those which subsequently failed.[22] Wong et al. showed that noninvasive blood flow velocity measured at 24 h is predictive of fistula success or failure.[15]

CONCLUSIONS

In our study, the cephalic vein diameter, arterial diameter and flow rate across the vein and anastomosis is the predominant factor determining the success of the proximal and distal arm fistulas. Preoperative Doppler study helps in the correct placement of fistula.

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Conflicts of interest
There are no conflicts of interest.

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