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Original Research Article

Impact of comorbidities and preoperative vascular assessment on outcomes of arteriovenous fistulas in patients on haemodialysis: a retrospective cohort study

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ABSTRACT

Background: End-stage renal disease is a major global health problem, and hemodialysis remains the most common renal replacement therapy. Arteriovenous fistula (AVF) is considered the gold-standard vascular access due to its superior patency and lower complication rates. However, AVF success depends on multiple factors, including vascular anatomy and patient comorbidities. Despite careful planning, a significant proportion of fistulas fail to mature or lose function over time. This study aimed to evaluate the impact of comorbidities and preoperative vascular assessment on AVF outcomes and to determine the relationship between vessel diameter and AVF success.
Methods: A retrospective cohort study was conducted at AIIMS Rishikesh including 150 adult chronic kidney disease (CKD) patients who underwent AVF creation. Data regarding demographics, comorbidities, duplex ultrasound findings, surgical details, complications, and patency outcomes were collected and analyzed statistically.
Results: The mean age was 48.2 years, with male predominance. Overall primary AVF success was 68.7%. Larger arterial and venous diameters were significantly associated with higher success rates, especially when both were ≥2 mm. Primary patency declined from 78% at 3 months to 45.1% at 12 months. Early thrombosis and failure to mature were the leading causes of primary failure. Diabetes and coronary artery disease (CAD), cerebrovascular accident (CVA), peripheral arterial disease (PAD) significantly reduced AVF success.
Conclusions: Preoperative vessel diameter is the strongest predictor of AVF success, while diabetes and systemic vascular disease negatively affect outcomes, emphasizing the importance of vascular assessment and comorbidity optimization.

Keywords: Arteriovenous fistula, AVF maturation, Comorbidities, Diabetes mellitus, Duplex ultrasound, End-stage renal disease, Hemodialysis, Patency, Vascular access, Vessel diameter

INTRODUCTION

End-stage renal disease (ESRD) represents a major global health challenge, and hemodialysis continues to be a primary modality of renal replacement therapy. Among the available vascular access options, a well-functioning arteriovenous fistula (AVF) is regarded as the preferred standard because of its longer patency and lower risk of complications compared with central venous catheters and synthetic grafts.[1] An AVF is an autologous vascular access formed by surgically connecting a vein to an adjacent artery, such as the cephalic vein to the radial artery, allowing the vein to serve as a reliable conduit for dialysis.[2] Proper creation and timely maturation of an AVF are essential for effective long-term dialysis and for improving patient quality of life.[3] The technique of

constructing a subcutaneous arteriovenous fistula between the radial artery and a nearby vein was first described by Cimino and Brescia in 1966, and since then, the Cimino fistula has been widely accepted as the optimal vascular access for hemodialysis.[4]

The success of AVF formation depends on multiple factors, including the size and quality of the arterial and venous vessels, the surgical approach, and patient-related characteristics. Among preoperative predictors, vessel diameter particularly that of the artery and vein plays a crucial role in determining the likelihood of primary AVF success. Patient factors such as older age, diabetes mellitus, and generalized atherosclerosis have also been identified as important contributors to primary AVF failure.[5,6] Preoperative duplex ultrasonography is commonly recommended to evaluate vascular anatomy, determine vessel suitability, and estimate the probability of successful AVF maturation.[7] Although duplex ultrasound is considered valuable for both preoperative planning and postoperative assessment of AVFs, the extent to which its routine preoperative use consistently improves overall AVF outcomes remains uncertain.[8,9]

Even with careful evaluation and surgical planning, a considerable number of AVFs do not mature sufficiently to support hemodialysis; these are referred to as primary failures. In addition, some fistulas may fail after a period of successful use, which is termed secondary failure. Such complications frequently require additional interventions, including fistuloplasty, thrombolytic therapy, or ligation of collateral vessels to restore or maintain vascular access.

Therefore, the primary objective of the study was to analyse the impact of comorbidities and pre operative vascular assessment on outcomes of arteriovenous fistulas created for patient on hemodialysis. Secondary objective was to determine the relation between preoperative vessel (artery and vein) diameter and the success rate of AVF creation and subsequent cannulation for hemodialysis.

METHODS

This retrospective cohort study was conducted in the Nephrology ward of AIIMS Rishikesh, Uttarakhand, India over 15 months (July 2024 to September 2025) and included adult patients with chronic kidney disease who underwent arteriovenous fistula (AVF) creation for hemodialysis. Patients were enrolled until June 2025 and followed for 3-12 months. A planned sample size of 200 patients was selected to ensure adequate power for outcome analysis, and all eligible cases during the study period were included when available. Patients aged ≥18 years with complete medical records, including preoperative Doppler reports, operative details, and follow-up data, were included, while those with incomplete records, arteriovenous grafts, peritoneal dialysis, or age <18 years were excluded.

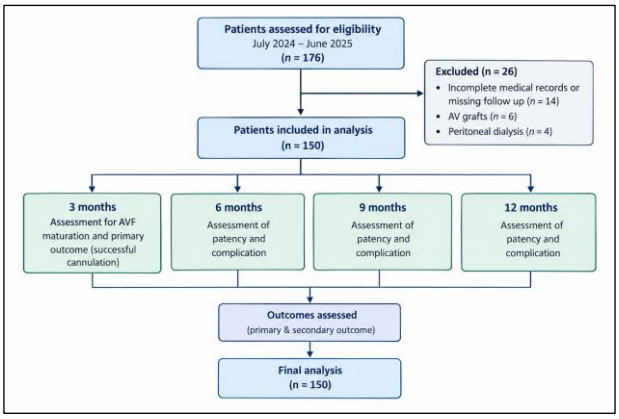

Figure 1: Study flow diagram.

Data were collected retrospectively from hospital records using a standardized form. Information included demographics, comorbidities (diabetes, hypertension, coronary artery disease, peripheral artery disease, obesity, and smoking), preoperative duplex ultrasound findings, and surgical details of AVF creation. Follow-up data included Doppler evaluation at 6 weeks, time to first cannulation, complications, interventions, and AVF patency status. Primary outcome was AVF success, defined as Successful use for dialysis with two-needle cannulation delivering prescribed blood flow within 3 months without additional intervention. Secondary outcomes included patency rates, failure patterns, complications, and associations with vessel diameter and comorbidities. Statistical analysis was performed using SPSS, with $p<0.05$ considered significant.

RESULTS

A total of 150 patients undergoing AVF creation were included in the study. The mean age was 48.2±15.3 years, with 42.7% of patients belonging to the 41-60 years age group. There was a male predominance, with 64.7% of patients were males in this cohort. Hypertension was the most common comorbidity (86.0%), followed by diabetes mellitus (45.3%) and CAD/CVA/PAD (28.0%). Nearly 38.7% of patients had two or more comorbidities. Radio-cephalic fistula was the most commonly created AVF type (74.7%), followed by brachio-cephalic fistula (21.3%). The mean arterial and venous diameters were 2.16±0.62 mm and 2.22±0.75 mm, respectively.

A strong association was observed between preoperative vessel diameter and AVF success. Success rates increased progressively with larger artery and vein diameter and highest success observed when both artery and vein diameter >2 mm (84%). Smaller vessel diameter either artery, vein or both, associated with higher failure rates. These findings were statistically significant ($p<0.001$). Primary and total AVF patency declined progressively over time. Primary patency decreased from 78% at 3 months to 45.1% at 12 months. Total patency declined from 85.3% to 66.2% over the 12 months. here we

included patient with patent AVF without intervention as well as patient with AVF successfully salvaged with intervention (endovascular/surgical) and successful cannulation done after intervention. patency loss increased steadily from 14.7% to 35.6 indicating gradual access failure during follow up. We included patient AVF not salvaged after intervention.

Table 1: Baseline demographic and clinical profile (n=150).

Characteristics	Category	Value
Age (years)	Mean±SD	48.2±15.3
	Range	18-79
	18-40 years, N (%)	51 (34.0)
	41-60 years, N (%)	64 (42.7)
	>60 years, N (%)	35 (23.3)
Sex	Male, N (%)	97 (64.7)
	Female, N (%)	53 (35.3)
Comorbidities	Hypertension, N (%)	129 (86.0)
	Diabetes mellitus, N (%)	68 (45.3)
	CAD/CVA/PAD, N (%)	42 (28.0)
	Smoking, N (%)	37 (24.7)
	No comorbidity, N (%)	15 (10.0)
	Two or more comorbidities, N (%)	58 (38.7)
AVF type	Radio-cephalic (RCF), N (%)	112 (74.7)
	Brachio-Cephalic (BCF), N (%)	32 (21.3)
	Brachio-Basilic/other, N (%)	6 (4.0)
Vessel diameter (mm)	Arterial (Mean±SD)	2.16±0.62
	Venous (Mean±SD)	2.22±0.75

CAD-coronary artery disease; CVA-ceberovascular accident; PAD-peripheral arterial disease

Table 2: Pre-operative vessel diameter and primary AVF success (n=150).

Category	Subgroup	Total	Primary success	Primary failure	Success rate (%)	P value
Arterial diameter (mm)	< 1.6	35	13	22	37.1	<0.001
	1.6-2.0	48	34	14	70.8	
	> 2.0	67	56	11	83.6	
Venous diameter (mm)	< 1.6	33	12	21	36.4	<0.001
	1.6-2.0	51	40	11	78.4	
	> 2.0	66	51	15	77.3	
Combined vessel diameter	Both <2.0 mm	42	18	24	42.9	<0.001
	Either ≥2.0 mm	58	43	15	74.1	
	Both ≥2.0 mm	50	42	8	84.0	
Overall	Total	150	103	47	68.7	-

P<0.05 significant

Primary AVF failure occurred in 31.3% patients and secondary failure occurred in 15.3% patients, resulting in overall AVF loss in 46.7%. Early Thrombosis (40.4%) and failure to mature or stenosis (38.3%) were the leading causes of primary failure, leading cause of secondary failure was stenosis (56.5%) followed by thrombosis. At the end of follow up, 53.3% of patient had functional AVF.

Diabetes mellitus and systemic vascular disease (CAD/CVA/PAD) were significantly associated with reduced AVF outcomes. Patients with diabetes had lower primary success (57.4% vs 78%, p=0.01) and reduced primary patency during 12 month follow up. Patients with systemic vascular disease had low primary success (54.8% vs 74.1%, p=0.02). smoking and hypertension reduced success of AVF but did not reach to significant level.

On multivariate analysis, arterial diameter showed a positive effect on AVF success (OR 3.18, p<0.001), where an increase in arterial size was associated with higher success rates and it emerged as the strongest predictor.

Venous diameter also demonstrated a positive effect (OR 2.24, p=0.006), with larger vein size being associated with improved AVF success and identified as a strong predictor. Diabetes mellitus (OR 0.34, p=0.01) and systemic vascular disease (OR 0.36, p=0.02) showed a negative effect on outcomes and associated with decreased AVF success. Age, sex, hypertension and smoking were not significantly associated with AVF outcomes.

Table 3: Patency rates at follow-up intervals (n=150).

Time interval	Patients at risk (N)	Primary patency, N (%)	Total patency (primary +secondary), N (%)	Patency loss (%)
3 months	150	117 (78.0)	128 (85.3)	14.7
6 months	124	80 (64.5)	98 (79.0)	23.5
9 months	97	51 (52.6)	70 (72.2)	30.7
12 months	71	32 (45.1)	47 (66.2)	35.6

Table 4: AVF failure rates and causes (n=150).

Comorbidity	Outcome measure	Present	Absent	P value
Diabetes mellitus	Number	68	82	
	Primary success, N (%)	39 (57.4)	64 (78.0)	0.01
	Primary patency at 6 months, N (%)	31/57 (54.4)	49/67 (73.1)	0.03
	Secondary patency at 12 months, N (%)	17/31 (54.8)	30/40 (75.0)	0.07
	Mean arterial diameter (mm)	2.07±0.57	2.24±0.65	0.09
CAD/CVA/ PAD	Number	42	108	
	Primary success, N (%)	23 (54.8)	80 (74.1)	0.02
	Primary patency at 6 months, N (%)	18/34 (52.9)	62/90 (68.9)	0.09
	Secondary patency at 12 months, N (%)	9/18 (50.0)	38/53 (71.7)	0.09
Smoking	Number	37	113	
	Primary success, N (%)	23 (62.2)	80 (70.8)	0.32
	Secondary patency at 12 months, n (%)	9/15 (60.0)	38/56 (67.9)	0.57
Hypertension	Number	129	21	
	Primary success, N (%)	87 (67.4)	16 (76.2)	0.42
	Secondary patency at 12 months, N (%)	39/60 (65.0)	8/11 (72.7)	0.62

P<0.005 significant; CAD-coronary artery disease; CVA-cerebrovascular accident; PAD-peripheral arterial disease

Table 5: Impact of comorbidities on AVF outcomes (n=150).

Comorbidity	Outcome measure	Present	Absent	P value
Diabetes mellitus	Number	68	82	
	Primary success, N (%)	39 (57.4)	64 (78.0)	0.01
	Primary patency at 6 months, N (%)	31/57 (54.4)	49/67 (73.1)	0.03
	Secondary patency at 12 months, N (%)	17/31 (54.8)	30/40 (75.0)	0.07
	Mean arterial diameter (mm)	2.07±0.57	2.24±0.65	0.09
CAD/CVA/PAD	Number	42	108	
	Primary success, N (%)	23 (54.8)	80 (74.1)	0.02
	Primary patency at 6 months, N (%)	18/34 (52.9)	62/90 (68.9)	0.09
	Secondary patency at 12 months, N (%)	9/18 (50.0)	38/53 (71.7)	0.09
Smoking	Number	37	113	
	Primary success, N (%)	23 (62.2)	80 (70.8)	0.32
	Secondary patency at 12 months, N (%)	9/15 (60.0)	38/56 (67.9)	0.57
Hypertension	Number	129	21	
	Primary success, N (%)	87 (67.4)	16 (76.2)	0.42
	Secondary patency at 12 months, N (%)	39/60 (65.0)	8/11 (72.7)	0.62

P<0.005 significant; CAD-coronary artery disease; CVA-cerebrovascular accident; PAD-peripheral arterial disease

Table 6: Multivariate logistic regression-predictors of primary AVF success (n=150).

Variable	Comparison	Odds Ratio (OR)	95% Confidence Interval	P value
Arterial diameter	Per 1 mm increase	3.18	1.62 - 6.24	<0.001
Venous diameter	Per 1 mm increase	2.24	1.26 - 3.98	0.006
Diabetes mellitus	Present vs. Absent	0.34	0.14 - 0.80	0.01
CAD/CVA/PAD	Present vs. Absent	0.36	0.15 - 0.87	0.02

Continued.

Variable	Comparison	Odds Ratio (OR)	95% Confidence Interval	P value
Age	Per 10 years increase	0.78	0.56 - 1.09	0.15
Hypertension	Present vs. Absent	0.69	0.26 - 1.82	0.45
Sex	Male vs. Female	1.28	0.52 - 3.15	0.59
Smoking	Yes vs. No	0.65	0.25 - 1.69	0.38

P<0.005 significant; CAD-coronary artery disease; CVA-cerebrovascular accident; PAD-peripheral arterial disease

DISCUSSION

The management of vascular access remains a critical cornerstone in optimizing outcomes for patients with end-stage renal disease (ESRD) undergoing maintenance haemodialysis. Autologous AVF superior to AV grafts and central venous catheters in terms of long-term patency and infection risk. For autologous AVF, early maturation failure and progressive patency loss remain formidable clinical challenges. In this retrospective cohort study conducted at AIIMS Rishikesh offers a comprehensive evaluation of how preoperative vascular anatomy and systemic comorbidity affect outcomes of AVF in patient on hemodialysis.

Our finding suggest that arterial and venous diameters are the strongest independent predictors of primary AVF success. This finding underscores the vital importance of objective preoperative duplex ultrasound mapping. Success rates increased significantly with larger arterial and venous diameters, reaching up to 84% when both vessels were ≥2 mm. Conversely, when both vessels fell below <2 mm, the success rate dropped precipitously to 42.9%. On multivariate analysis, arterial diameter emerged as the strongest independent predictor of AVF success, followed by venous diameter, while diabetes and systemic vascular disease were significant negative predictors. Multivariate logistic regression firmly validated this, revealing that each ≥1 mm increase in baseline arterial and venous diameters increased the odds of primary success by 3.18-fold and 2.24-fold, respectively. These findings closely align with the work of Kim et al and Hossain et al, who previously established ultrasound-measured vascular Caliber as pivotal predictor of access maturation.[10,11]

Poiseuille's Law, which dictates that fluid vascular resistance is inversely proportional to the fourth power of the vessel radius. So high blood flow in low diameter vessel increase resistance which leads to endothelia shear stress. This physical shear stress activates endothelial nitric oxide synthase (eNOS), inducing the remodelling and medial hypertrophy characteristic of successful AVF maturation. When baseline calibers are small (<2.0 mm), the structural threshold to accommodate this high-velocity flow without collapsing or inducing immediate turbulence is severely compromised. This explains primary failure of AVF in small caliber vessel.

Diabetes mellitus and advanced macrovascular disease (CAD/CVA/PAD) are independent negative predictors of AVF success in our multivariate model. Patients with diabetes exhibited a primary success rate of only 57.4% compared to 78.0% in non-diabetic controls. Diabetes triggers accelerated medial arterial calcification (Mönckeberg's sclerosis) and advanced glycation end-product (AGE) cross-linking within the vascular extracellular matrix. This reduce passive dilation of artery required to feed the newly created low resistance venous circuit. These results are comparable to those of Kim et al and Jhee et al, who also emphasized that increasing comorbidity burden adversely affects vascular access outcomes, supporting the present findings that systemic vascular diseases negatively influence AVF maturation and function.[10,13]

Our analysis indicates that while early primary failure is driven by acute thrombotic events and failure to mature, late secondary failure is overwhelmingly driven by localized stenosis (56.5%). This late-stage stenosis typically occurs due to turbulent shear stress profiles at the juxta-anastomotic site or repetitive trauma from hemodialysis needle cannulation, which provokes localized smooth muscle cell proliferation. while hypertension and smoking showed trends toward reduced success possibly due to macrovascular damage, they did not reach statistical significance in our model.

This study has certain limitations that must be considered when interpreting our conclusions. First, its retrospective, single-center design susceptible to selection bias and may limit the generalizability of our results to different regions. Second, we observed a substantial drop in follow-up completeness, decreasing from 82.7% at six months to 47.3% at twelve months. Third, our dataset lacked intraoperative variables such as the type of anesthesia used (regional blocks versus local infiltration) or the occurrence of intraoperative venospasms, which can temporarily alter vessel diameters and influence early patency.

CONCLUSION

The study population was predominantly middle-aged and male, with a high prevalence of hypertension and diabetes. Larger arterial and venous diameters were strongly associated with higher success rates, with the best outcomes observed when both vessels were ≥2.0 mm. Primary and secondary patency declined over time. Early thrombosis and failure to mature were the main causes of primary failure, while stenosis was the leading cause of secondary failure. Arterial diameter was the strongest predictor of success, whereas diabetes and systemic vascular disease negatively affected outcomes. For nephrologists and vascular surgeons, these findings emphasize that preoperative ultrasound planning must be coupled with rigorous comorbidity optimization.

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