RESEARCH PAPER

Predictors of Arteriovenous Fistula Maturation in Patients with End-Stage Kidney Disease: A Prospective Cohort Study from South India

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ABSTRACT:

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INTRODUCTION

Chronic kidney disease (CKD) deaths in India increased from 0.59 million in 1990 to 1.18 million in 2016. Due to the lack of kidney failure registries, the incidence and prevalence of kidney failure are still estimated. The Million Death Study estimated kidney failure deaths at 136,000 in 2015, [1,2]. In 2018, it was estimated that around 175,000 patients in India were undergoing chronic dialysis, which corresponds to a prevalence rate of 129 per million people. A systematic review from 2010 found that nearly two-thirds of patients with kidney failure died without receiving dialysis. The impact of kidney failure deaths in India is notably higher than in other low- and middle-income countries with similar sociodemographic profiles, indicating that it is feasible to achieve better mortality rates in India using current resources. Additionally, in absolute and relative terms, fewer kidney failure patients in India have access to treatment and insurance coverage compared to China, the only other populous nation. [3,4]

Hemodialysis (HD) is India's primary renal replacement therapy (RRT). The first HD procedure took place in 1961 at Christian Medical College in Vellore, Tamil Nadu, involving a former Maharaja and led by Dr. Satoru Nakamoto from Seattle. Initially, growth was slow, with HD performed only in a limited number of public and private hospitals in major cities until the 1990s. However, over the past twenty years, the number and spread of HD units have significantly increased, ensuring dialysis services are now accessible throughout all 28 states and eight union territories. [5]

The development and growth of arteriovenous fistulas (AVF) for hemodialysis (HD) are vital for effective dialysis treatment. The maturation success rates of arteriovenous fistulas (AVF) can fluctuate, with estimated patency rates around 60% after one year and

approximately 51% after two years. Successful AVF maturation is influenced by factors such as vessel quality and diameter, the experience of the surgeon, and hemodynamic conditions. For patients at higher risk of maturation failure, using Doppler ultrasound to evaluate and select appropriate vessels for AVF creation is advisable. Although vascular parameters are linked to maturation outcomes, other clinical characteristics have not consistently shown a connection to successful AVF maturation in predictive study models. [6,8]

AVF maturation failure remains a daily challenge for specialists focused on vascular access for HD. Despite advancements in technology and techniques, accurately predicting maturation remains a problem. [9]

METHODOLOGY

Study Design and Setting: This observational cohort study was conducted from March 2024 to March 2025 in department of vascular surgery , Saveetha medical college , chennai , India.

Study Population: The study included patients aged 18 and above with stage V chronic kidney disease (CKD) who were either on maintenance dialysis or preparing for it, and who were referred for their first arteriovenous fistula (AVF) creation. Those who died before the AVF evaluation or were lost to follow-up were excluded. Ethical approval was secured from the Institutional Ethics Committee, and all participants provided written informed consent in accordance with the Indian Council of Medical Research (ICMR) guidelines.

Data Collection and Variables: During the creation of the AVF, a trained dialysis nurse or clinical investigator gathered baseline data using a structured form. This data encompassed demographics, including age, gender, and socioeconomic status, as well as CKD classification, coexisting conditions like diabetes, hypertension, and tobacco use, antiplatelet medication use, and prior vascular access history. Anthropometric measurements such as body mass index (BMI), arm circumference, and skinfold thickness were recorded. Blood pressure was measured twice and averaged, following Indian nephrology practice standards.

Vascular Assessment and Surgical Procedure: All patients underwent preoperative vascular mapping using Doppler ultrasonography. The assessment concentrated on the cephalic, basilic, and brachial veins and the brachial, radial, and ulnar arteries. A certified radiologist performed these evaluations employing a high-frequency linear transducer (7.5–10 MHz), which is becoming increasingly common for dialysis access planning in India. The optimal location for AVF creation was determined based on the quality of the vessels and their anatomical suitability. Skilled vascular surgeons then surgically established all AVFs using a standardized technique: local anesthesia, atraumatic dissection, intravenous heparin (1:100 dilution), and end-to-side anastomosis with 6–0 or 7–0 polypropylene sutures. The primary AVF types performed included radiocephalic, brachiocephalic, and brachiobasilic, following standard practices in India.

Follow-up and Outcome Assessment: Postoperative care involved counseling patients about limb protection and AVF hygiene. Patients were scheduled for a Doppler ultrasound reassessment 4 to 6 weeks after surgery. According to KDOQI and Indian Society of Nephrology guidelines, AVF maturation was defined by a venous diameter of ≥0.4 cm and a blood flow rate of ≥500 mL/min.

Statistical Analysis: Continuous variables were expressed as means and standard deviations, whereas categorical data were shown as proportions. Group comparisons were made using the Student’s t-test and

chi-square test. Logistic regression assessed factors associated with AVF maturation. A multivariate logistic regression model included variables with a p-value <0.20 from univariate analysis. Due to collinearity between arm circumference and skinfold thickness (r^2 = 0.68), these two variables were analyzed in separate models. A p-value <0.05 was considered statistically significant. Statistical analyses were conducted using SPSS version 27.

OBSERVATIONS AND RESULTS

The study included a total of 250 patients, with 195 (78%) having mature arteriovenous fistulas (AVFs) and 55 (22%) having immature AVFs. The cohort had a mean age of 63, and 60.8% were male. Obesity (BMI ≥ 30) was notably more common in patients with immature AVFs (47.3%) compared to those with mature AVFs (34.9%) (p = 0.021). Regarding chronic kidney disease (CKD) etiologies, significant differences were found between groups for polycystic kidney disease (25.5% vs. 9.7%, p = 0.004) and chronic glomerulonephritis (1.8% vs. 14.9%, p = 0.010). Hematocrit levels were higher in patients with immature AVFs (median 35.2%) versus mature AVFs (32.8%, p = 0.017). (Table 1)

Anatomical and vascular traits, those with immature AVFs had larger arm circumferences (median 32 cm vs. 28 cm, p = 0.001) and greater skinfold thickness (2.8 cm vs. 2.0 cm, p = 0.001). They also had smaller artery diameters (0.3 cm vs. 0.4 cm, p = 0.001) and were more likely to have AVFs located at the forearm level (62.5% vs. 28.3%, p < 0.001). Brachiocephalic AVFs were more frequent in the mature group (50.4% vs. 31.2%, p = 0.033), while radiocephalic AVFs were predominant in the immature group (59.4%). (Table 2)

Univariate logistic regression analysis indicated that higher BMI (OR = 0.43, p = 0.019), hematocrit (OR = 0.45, p = 0.011), smaller vein diameter (OR = 0.46, p = 0.002), and distal AVF placement (OR = 5.54, p = 0.001) correlated with reduced odds of maturation. Conversely, increased arm circumference (OR = 3.78, p = 0.001) and artery diameter ≥4.0 mm (OR = 3.81, p = 0.001) were strong positive indicators. ((Table 3)

Multivariate logistic regression confirmed that a larger median vein diameter (OR = 4.82–6.67, p = 0.001–0.002), elevated systolic blood pressure (OR = 2.22, p = 0.017), and increased arm circumference (OR = 2.91, p < 0.001) were independently linked to successful AVF maturation. In contrast, smoking (OR = 0.01–1.42, p = 0.004–0.032) and greater skinfold thickness (OR = 0.01, p < 0.001) significantly lowered the chances of AVF maturation. (Table 4)

DISCUSSION

This study shows a notable arteriovenous fistula (AVF) maturation success rate of 78%, surpassing rates generally reported in international literature. This includes a meta-analysis of 46 studies that indicated lower average maturation rates outcomes. [10] The successful outcomes can be linked to the proper use of preoperative Doppler ultrasound mapping by vascular surgeons, facilitating improved vessel selection and site planning. In India, where the quality of dialysis care varies significantly and AVF failure presents a substantial obstacle to efficient hemodialysis delivery, this structured preoperative evaluation appears essential. [11,12]

Within this group, factors such as current or past smoking, elevated body mass index (BMI), greater arm circumference, and increased skinfold thickness were associated with a reduced likelihood of arteriovenous fistula (AVF) maturation. These findings support earlier research that links obesity and tobacco consumption to adverse AVF outcomes. Specifically, skinfold thickness and arm circumference—anthropometric measures of localized fat and muscle—independently predicted failure, underscoring their potential value in pre-surgical risk assessment, an area rarely explored in studies conducted in India elsewhere.[13]

In contrast, elevated systolic blood pressure and greater vein diameter prior to surgery were significant, independent predictors of successful maturation of the arteriovenous fistula (AVF). This finding aligns with earlier research that emphasizes the role of vessel size and blood flow dynamics. The beneficial impact of systolic blood pressure may relate to improved hemodynamic flow following the connection. However, the effect of antihypertensive treatment was not able to be evaluated because of the study's reliance on a single measurement point. [14,15]

Interestingly, although male sex and proximal AVF placement appeared beneficial in univariate analysis, their significance diminished in multivariate modeling. This finding aligns with global literature that reveals inconsistent gender differences in AVF outcomes. Establishing AVFs in the proximal arm, which typically has a larger vein diameter, supports current clinical preferences for brachiocephalic configurations in suitable anatomical situations cases. [16]

This cohort study contributes valuable insights to the limited literature available from India regarding predictors of AVF maturation, particularly focusing on anthropometric measurements like skinfold thickness and arm circumference. However, the study presents limitations such as a short maturation assessment, a lack of flow rate measurements during hemodialysis, and the absence of longitudinal blood pressure monitoring. Moreover, Doppler evaluations were not conducted in a double-masked manner, which could introduce observer bias.

Despite these limitations, our results validate the clinical importance of preoperative vascular mapping, highlight anthropometric factors as key predictors, and stress the necessity for personalized access planning in Indian dialysis patients. Further multicentric studies involving various patient groups across India must confirm these predictors and enhance national vascular access outcomes.

REFERENCES

1. Xie Y, Bowe B, Mokdad AH, Xian H, Yan Y, Li T, Maddukuri G, Tsai CY, Floyd T, Al-Aly Z: Analysis of the Global Burden of Disease study highlights the global, regional, and national trends of chronic kidney disease epidemiology from 1990 to 2016. Kidney Int 94: 567–581, 2018.
2. Dare AJ, Fu SH, Patra J, Rodriguez PS, Thakur JS, Jha P; Million Death Study Collaborators: Renal failure deaths and their risk factors in India 2001-13: Nationally representative estimates from the million death study. Lancet Glob Health 5: e89–e95, 2017.
3. Jha V, Ur-Rashid H, Agarwal SK, Akhtar SF, Kafle RK, Sheriff R; ISN South Asia Regional Board: The state of nephrology in South Asia. Kidney Int 95: 31–37, 2019. 10.1016/j.kint.2018.09.001
4. Liyanage T, Ninomiya T, Jha V, Neal B, Patrice HM, Okpechi I, Zhao MH, Lv J, Garg AX, Knight J, Rodgers A, Gallagher M, Kotwal S, Cass A, Perkovic V: Worldwide access to treatment for end-stage kidney disease: A systematic review. Lancet 385: 1975–1982, 2015. 10.1016/S0140-6736(14)61601-9
5. Chugh KS: Five decades of Indian nephrology: A personal journey. Am J Kidney Dis 54: 753–763, 2009.
6. Al-Jaishi AA, Oliver MJ, Thomas SM, Lok CE, Zhang JC, Garg AX, et al. Patency rates of the arteriovenous fistula for hemodialysis: a systematic review and meta-analysis. Am J Kidney Dis. 2014;63(3):464-78.
7. Lopes JRA, Marques ALB, Correa JA. The influence of a Doppler ultrasound in arteriovenous fistula for dialysis failure

related to some risk factors. J Bras Nefrol. 2020;42(2):147 52.

8. Malovrh M. The role of sonography in the planning of arteriovenous fistulas for hemodialysis. Semin Dial. 2003;16(4):299-303.
9. Barbosa WM, Franco RP, Rodrigues AT. Arteriovenous fistulas maturation: predictors of maturation and use of ultrasound. J Bras Nefrol. 2023 Jul-Sep;45(3):272-273
10. Al-Jaishi AA, Oliver MJ, Thomas SM, Lok CE, Zhang JC, Garg AX, et al. Patency rates of the arteriovenous fistula for hemodialysis: a systematic review and meta-analysis. Am J Kidney Dis. 2014;63(3):464-78.
11. Nursal TZ, Oguzkurt L, Tercan F, Torer N, Noyan T, Karakayali H, et al. Is routine preoperative ultrasonographic mapping for arteriovenous fistula creation necessary in patients with favorable physical examination findings? Results of a randomized controlled trial. World J Surg. 2006;30(6):1100-7.
12. Ferring M, Claridge M, Smith SA, Wilmink T. Routine preoperative vascular ultrasound improves patency and use of arteriovenous fistulas for hemodialysis: a randomized trial. Clin J Am Soc Nephrol. 2010;5(12):2236-44.
13. Chan MR, Young HN, Becker YT, Yevzlin AS. Obesity as a predictor of vascular access outcomes: USRDS DMMS Wave II study analysis. Semin Dial. 2008;21(3):274 9.
14. Rooijens PP, Tordoir JH, Stijnen T, Burgmans JP, Smet de AA, Yo TI. Radiocephalic wrist arteriovenous fistula for hemodialysis: meta-analysis indicates a high primary failure rate. Eur J Vasc Endovasc Surg. 2004;28(6):583-9.
15. Brimble KS, Rabbat CG, Treleaven DJ, Ingram AJ. Utility of ultrasonographic venous assessment before forearm arteriovenous fistula creation. Clin Nephrol. 2002;58(2):122 7.
16. Siddiqui MA, Ashraff S, Carline T. Maturation of arteriovenous fistula: analysis of key factors. Kidney Res Clin Pract. 2017;36(4):318-28

TABLES

Table 1: Characteristics of the Study Population in general and Stratified based on AVF Maturation Status

	Total (n = 250)	Mature AVF (n = 195)	Immature AVF (n = 55)	P value
Age (years)	63.0 (54–70)	64.0 (56–71)	61.0 (50–68)	0.296, ns
Sex (Male)	152 (60.8%)	125 (64.1%)	27 (49.1%)	0.070,ns
BMI (kg/m²)	29.5 (25–33)	28.7 (25–32)	33.0 (28–36)	0.141, ns
Obese (BMI ≥ 30)	94 (37.6%)	68 (34.9%)	26 (47.3%)	0.021*, sig
SBP (mmHg)	145 (135–165)	150 (140–165)	138 (125–160)	0.125,ns
DBP (mmHg)	91 (85–100)	92 (88–100)	88 (80–100)	0.495,ns
Hemodialysis	149 (59.6%)	119 (61.0%)	30 (54.5%)	0.179, ns
Etiology of CKD: DM	91 (36.4%)	72 (36.9%)	19 (34.5%)	0.762, ns
Etiology of CKD: SH	70 (28.0%)	55 (28.2%)	15 (27.3%)	0.891, ns
Etiology of CKD: PKD	33 (13.2%)	19 (9.7%)	14 (25.5%)	0.004*, sig
Etiology of CKD: CGN	30 (12.0%)	29 (14.9%)	1 (1.8%)	0.010*, sig
Etiology of CKD: TIN	28 (11.2%)	21 (10.8%)	7 (12.7%)	0.709, ns
Etiology of CKD: Undefined	7 (2.8%)	5 (2.6%)	2 (3.6%)	0.665, ns
Hematocrit (%)	33.5 (28–38)	32.8 (28–36)	35.2 (30–40)	0.017*, sig
Hemoglobin (g/dL)	12.5 (10–14)	12.2 (10–14)	13.2 (11–15)	0.050, ns
Platelets (×10³/μL)	221 (185–267)	223 (190–270)	217 (175–250)	0.500, ns
Systemic Hypertension	240 (96.0%)	188 (96.4%)	52 (94.5%)	0.352, ns
Diabetes	122 (48.8%)	94 (48.2%)	28 (50.9%)	0.927,ns
Anti-platelet drugs	60 (24.0%)	45 (23.1%)	15 (27.3%)	0.550, ns
Smoking (Present/Past)	110 (44.0%)	83 (42.6%)	27 (49.1%)	0.141, ns
Previous CT (same side)	6 (2.4%)	3 (1.5%)	3 (5.5%)	0.635, ns

TABLE 2: Anatomical and Vascular Characteristics of the Study Population by aVF Maturation Status

	Total (n = 250)	Mature AVF (n = 195)	Immature AVF (n = 55)	P value
Arm circumference (cm)	29 (26–33)	28 (25–30)	32 (28–36)	0.001*, sig
Skinfold thickness (cm)	2.4 (1.6–3.2)	2.0 (1.4–2.9)	2.8 (2.3–3.7)	0.001*, sig
Vein pre-AVF (cm)	0.4 (0.3–0.4)	0.4 (0.3–0.4)	0.3 (0.3–0.4)	0.093,ns
Artery pre-AVF (cm)	0.4 (0.3–0.5)	0.4 (0.3–0.5)	0.3 (0.2–0.4)	0.001*, sig
Side: Right	81 (32.4%)	64 (32.7%)	17 (31.2%)	0.873, ns
Side: Left	169 (67.6%)	131 (67.3%)	38 (68.7%)	
Height: Arm	160 (64.1%)	140 (71.7%)	21 (37.5%)	0.001*, sig
Height: Forearm	90 (35.9%)	55 (28.3%)	34 (62.5%)	
AVF: Brachiocephalic	116 (46.2%)	98 (50.4%)	17 (31.2%)	0.033*, sig
AVF: Radiocephalic	91 (36.5%)	59 (30.1%)	33 (59.4%)	
AVF: Brachiobasilic	31 (12.4%)	28 (14.2%)	3 (6.2%)	
AVF: Brachio-perforating	7 (2.8%)	7 (3.5%)	0 (0.0%)	
AVF: Brachio-brachial	5 (2.1%)	4 (1.8%)	2 (3.1%)	

TABLE 3: Univariate Analysis of AVF Maturation Predictors

	Adjusted OR	Adjusted 95% CI	p-value (n = 250)

Sex (male vs. female)	1.57	0.01–3.4	0.056
Age (per year)	3.53	3.5–3.56	0.331
BMI (per unit)	0.43	0.38–0.48	0.019
Diabetes (yes vs. no)	0.01	0.01–0.91	0.809
Smoking (past/present vs. never)	1.81	1.33–2.29	0.355
Hematocrit (per unit)	0.45	0.4–0.51	0.011
Hemoglobin (per unit)	0.01	0.01–0.05	0.562
Platelets (per unit)	1.71	1.71–1.71	0.445
SBP (per mmHg)	0.01	0.01–0.03	0.811
DBP (per mmHg)	0.01	0.01–0.06	0.359
Anti-platelet drugs (yes vs. no)	3.27	2.5–4.04	0.671
Median vein diameter (≥ 3.6 mm vs. < 3.6 mm)	0.46	0.01–3.25	0.002
Median artery diameter (≥ 4.0 mm vs. < 4.0 mm)	3.81	0.47–7.15	0.001
Arm circumference (per unit)	3.78	3.71–3.85	0.001
Previous catheter (yes vs. no)	2.07	0.01–5.22	0.739
AVF site (proximal vs. distal)	5.54	1.83–9.25	0.001
Skinfold thickness (per unit)	1.16	0.95–1.36	0.001

TABLE 4: Multivariate Analysis of Variables associated with arteriovenous Fistula maturation

	Adjusted OR	Adjusted 95% CI	p-value (n = 250)
Smoking (past/present vs. never)	1.42	1.03–1.8	0.032
SBP (per mmHg)	2.22	2.2–2.25	0.017
Median vein diameter (≥ 3.6 mm vs. < 3.6 mm)	4.82	0.01–11.06	0.001
Arm circumference (per unit)	2.91	2.83–2.99	< 0.001
Smoking (past/present vs. never)	0.01	0.01–0.29	0.004
SBP (per mmHg)	0.01	0.01–0.04	0.018
Median vein diameter (≥ 3.6 mm vs. < 3.6 mm)	6.67	0.8–12.54	0.002
Skinfold thickness (per unit)	0.01	0.01–0.2	< 0.001