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Factors associated with arteriovenous fistula failure among patients with stage 5 chronic kidney disease receiving hemodialysis: A retrospective study in Indonesia

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Abstract

Arteriovenous fistula (AVF) is the preferred vascular access for maintenance hemodialysis; however, failure to achieve or maintain functional access remains a major clinical challenge. The aim of this study was to identify factors associated with AVF failure among patients with stage 5 chronic kidney disease undergoing hemodialysis. A retrospective observational study was conducted at the Hemodialysis Unit of Saiful Anwar Hospital, Malang, Indonesia, between November 2021 and January 2022. Demographic and clinical data were extracted from medical records. Bivariate analyses were performed to identify potential associated factors, and variables with $p<0.25$ were subsequently entered into a multivariable logistic regression model. Overall, 32.0% of patients experienced AVF failure, whereas 68.0% achieved successful AVF use. In the bivariate analyses, sex, education level, previous vascular access type, history of AVF repair, interval between chronic kidney disease diagnosis and AV shunt placement, time to AV shunt usability, duration of AV shunt use, post-intervention AV shunt usability, and diabetes mellitus were associated with AVF failure. After multivariable adjustment, only previous vascular access type remained independently associated with AVF failure. Previous AV shunt use was associated with substantially lower odds of AVF failure (adjusted odds ratio: 0.0046; 95% confidence interval: 0.00002–0.110; $p=0.009$). Other demographic and clinical factors were no longer statistically significant after adjustment. These findings suggest that previous vascular access type was independently associated with AVF failure in hemodialysis patients, highlighting the importance of optimizing vascular access selection to improve AVF outcomes. Prospective multicenter studies with larger populations are warranted to confirm this association and clarify its clinical relevance.

Keywords: Chronic kidney disease, hemodialysis, vascular access, arteriovenous fistula, treatment outcome

Introduction

Chronic kidney disease (CKD) has emerged as a major global health challenge, imposing a substantial and growing burden on healthcare systems worldwide [1]. Approximately one in ten adults is affected by CKD, with morbidity and mortality increasing markedly among patients with advanced disease who require kidney replacement therapy, particularly hemodialysis [2]. The effectiveness of hemodialysis is influenced by several patient- and treatment-related factors, including clinical condition, comorbidities, nutritional status, and the quality of vascular access

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[3]. Reliable vascular access is essential for the safe and sustained delivery of hemodialysis [3]. Inadequate vascular access may predispose patients to thrombosis, infection, and access failure, thereby increasing morbidity and disrupting treatment continuity [4]. Moreover, the type of vascular access may influence dialysis adequacy and the risk of hospital readmission [5]. Therefore, appropriate selection, establishment, and maintenance of vascular access are critical for improving clinical outcomes among patients with CKD undergoing hemodialysis.

Arteriovenous fistula (AVF) is the preferred vascular access for patients undergoing hemodialysis because of its superior long-term patency and lower risk of complications compared with other access modalities [6]. Nevertheless, AVF failure remains a major clinical challenge and may result from impaired vascular maturation, endothelial dysfunction, thrombosis, and inadequate blood flow [7,8]. Several patient- and procedure-related factors, including diabetes mellitus, poor vascular condition, and delayed AVF creation, have been associated with an increased risk of failure. However, findings across studies remain inconsistent, and the clinical factors independently associated with AVF failure have not been fully established [9,10]. In addition, AVFs are susceptible to structural and functional alterations mediated by chronic inflammation and oxidative stress, both of which may contribute to vascular dysfunction and unsuccessful maturation [8,11]. Further investigation is therefore required to clarify the factors associated with AVF failure among patients with CKD receiving hemodialysis. The aim of this study was therefore to identify demographic and clinical factors associated with AVF failure among patients with CKD undergoing hemodialysis. The findings are expected to improve understanding of AVF outcomes and inform clinical decision-making regarding vascular access selection and management.

Methods

Study design

A retrospective study was conducted at the Hemodialysis Unit of Saiful Anwar Hospital Malang, Indonesia, from November 2021 until January 2022. The purpose of this study is to investigate the characteristics that contribute to AVF failure in patients with stage 5 CKD being treated with hemodialysis. The study included the analysis of the demographic and clinical characteristics that may contribute to AVF failure. The research protocol was developed using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [12]. All study procedures were conducted in accordance with the principles of the Declaration of Helsinki.

Participants and eligibility criteria

Eligible patients were identified using total sampling, whereby all medical records meeting the predefined eligibility criteria during the study period were included. Patients were eligible if they had stage 5 CKD, were undergoing hemodialysis, and had undergone AVF placement. Patients with incomplete medical record data were excluded. Overall, 97 patients were included and classified into the AVF failure group (n=31) or AVF success group (n=66).

Data collection

Data were retrospectively extracted from the medical records of eligible patients treated at the Hemodialysis Unit of Saiful Anwar Hospital between November 2021 and January 2022. The extracted information comprised demographic characteristics, relevant clinical parameters, the type of vascular access used before AVF placement, and subsequent AVF outcomes, including failure or successful use. Data extraction was performed by two investigators (KAR and AR). Whenever inconsistencies or discrepancies were identified, the corresponding medical records were re-examined, and the extracted information was cross-verified to ensure the accuracy, completeness, and consistency of the study dataset.

Study variables

The primary outcome was AVF status, categorized as failure or successful use. AVF failure was defined as primary failure, including loss of bruit or thrill within 72 hours after creation, failure to achieve functional maturation within three months, or early thrombosis that rendered the fistula unsuitable for hemodialysis. AVF success was defined as a mature and functional fistula capable of supporting the prescribed hemodialysis regimen using two-needle cannulation in more than two-thirds of dialysis sessions over four consecutive weeks without the need for additional intervention [13].

The demographic variables included age, categorized as ≤50 or >50 years; sex; educational attainment, categorized as no formal education, elementary school, middle school, high school, or diploma/undergraduate education; employment status, categorized as employed or unemployed; weight; height; and body mass index (BMI). Clinical variables included the type of vascular access used before AVF placement, categorized as AV shunt, double-lumen catheter, or manual access; history of AVF repair; interval between CKD diagnosis and AV shunt placement, categorized as <6, 6–12, or >12 months; time from AV shunt placement to initial use; duration of AV shunt use; intervention performed following AVF failure; and AV shunt location, categorized as radiocephalic or brachiocephalic. Comorbidities included diabetes mellitus and hypertension. Diabetes mellitus was recorded according to its presence or absence and categorized by duration as ≤3 or >3 years, whereas hypertension was recorded according to its presence or absence and categorized by duration as ≤6 or >6 years.

Statistical analysis

Categorical variables were summarized as frequencies and percentages, whereas continuous variables were presented as mean±standard deviation (SD) for normally distributed data or median with interquartile range (IQR) for non-normally distributed data. The distribution of continuous variables was assessed using the Shapiro–Wilk test. Bivariate analyses were conducted to evaluate the association between each demographic or clinical variable and AVF failure, using statistical tests selected according to the type and distribution of the data. Variables with $p<0.25$ in the bivariate analyses were entered into a multivariable logistic regression model to adjust for potential confounding and identify factors independently associated with AVF failure. The magnitude of each association was expressed as an odds ratio (OR) with a 95% confidence interval (CI). A $p<0.05$ was considered statistically significant. All analyses were performed using GraphPad Prism (GraphPad Software, California, USA).

Results

Baseline characteristics of patients

A total of 97 patients with stage 5 CKD undergoing hemodialysis were included, of whom 31 (32.0%) experienced AVF failure, and 66 (68.0%) achieved successful AVF use. Among patients with AVF failure, 61.3% were aged ≤50 years and 61.3% were male, whereas 45.5% of those with successful AVF use were aged ≤50 years and 39.4% were male. The median BMI was 21.48 kg/m^2 (IQR: 20.44–23.14) in the AVF failure group and 22.41 kg/m^2 (IQR: 21.31–26.22) in the AVF success group. Radiocephalic AVFs were the most frequently used fistula location in both groups, accounting for 77.4% and 81.8% of patients, respectively. Diabetes mellitus was present in 48.4% of patients with AVF failure and 12.1% of those with successful AVF use, whereas hypertension was present in 83.9% and 78.8%, respectively. The complete demographic and clinical characteristics are presented in **Table 1**.

Bivariate analysis of factors associated with arteriovenous fistula (AVF) failure

Bivariate analysis of factors associated with AVF failure is presented in **Table 1**. Male sex was associated with higher odds of AVF failure than female sex (OR: 2.44; 95%CI: 1.02–5.68; p=0.043). Previous vascular access type was also significantly associated with AVF failure. Previous AV shunt use was associated with lower odds of failure (OR: 0.01; 95%CI: 0.001–0.02; $p<0.001$), whereas previous double-lumen catheter use (OR: 58.18; 95%CI: 12.28–261.70; $p<0.001$) and manual access (OR: 13.09; 95%CI: 2.90–62.18; $p<0.001$) were associated with higher odds of failure. A history of AVF repair was similarly associated with AVF failure (OR: 9.33; 95%CI: 1.78–45.72; p=0.002) (**Table 1**).

Table 1. Baseline characteristics and bivariate associations with arteriovenous fistula (AVF) failure among patients with stage 5 chronic kidney disease (CKD) receiving hemodialysis

Variable	Arteriovenous (AVF) fistula		Odds ratio or mean difference	95% confidence interval	*p*-value
	AVF failure (n=31) n (%)	AVF success (n=66) n (%)			
Age (years)					
≤50	19 (61.3)	30 (45.5)	1.90	0.80–4.38	0.145
>50	12 (38.7)	36 (54.5)	0.53	0.23–1.25	0.145
Gender					
Male	19 (61.3)	26 (39.4)	2.44	1.02–5.68	0.043
Female	12 (38.7)	40 (60.6)	0.41	0.18–0.98	0.043
Education					
No formal education	2 (6.5)	0 (0.0)	+infinity	1–+infinity	0.037
Primary school	9 (29.0)	16 (24.2)	1.28	0.51–3.21	0.615
Elementary school	0 (0.0)	10 (15.2)	0.00	0.00–0.67	0.022
High school	14 (45.2)	20 (30.3)	1.89	0.78–4.51	0.152
Bachelor’s degree/diploma	6 (19.3)	20 (30.3)	0.55	0.19–1.48	0.256
Employment status					
Working	15 (48.4)	41 (60.6)	0.61	0.25–1.46	0.257
Not working	16 (51.6)	25 (39.4)	1.64	0.69–4.01	0.257
Weight, median (interquartile range (IQR))	58 (50.50–60.50)	59 (50–65.75)	-1.00	-8.00–1.00	0.118
Height, median (IQR)	160 (154.5–165.0)	157 (150.0–165.0)	3.00	-2.00–5.00	0.632
BMI, median (IQR)	21.48 (20.44–23.14)	22.41 (21.31–26.22)	-0.84	-2.57–0.13	0.083
Previous access used					
AV shunt	2 (6.5)	62 (94)	0.01	0.001–0.02	<0.001
Double lumen	20 (64.5)	2 (3.0)	58.18	12.28–261.7	<0.001
Manual	9 (29.0)	2 (3.0)	13.09	2.9–62.18	<0.001
AVF repaired	7 (22.6)	2 (3.0)	9.33	1.78–45.72	0.002
Time interval between CKD diagnosis and AV shunt placement (months)					
<6	5 (16.1)	45 (68.2)	0.09	0.04–0.25	<0.001
6–12	4 (12.9)	10 (15.2)	0.83	0.27–2.90	0.768
>12	22 (71)	11 (16.6)	12.22	4.18–35.02	<0.001
Time from AV shunt placement to usability (months)					
<6	29 (93.6)	66 (100.0)	0.00	0.00–0.99	0.037
6–12	2 (6.6)	0 (0.0)	Infinity	1.00–+infinity	0.037
Duration of AV shunt usability (months)					
<6	29 (93.6)	2 (3.0)	464.00	59.73–2402.00	<0.001
6–12	2 (6.4)	2 (3.0)	2.21	0.33–14.49	0.429
>12	0 (0.0)	62 (94.0)	0.00	0.00–0.01	<0.001
Subsequent intervention after AV shunt failure					
New AV shunt placement	27 (87.2)	63 (95.5)	0.32	0.08–1.28	0.138
Double-lumen catheter insertion	2 (6.4)	1 (1.5)	4.48	0.50–65.77	0.190
AV shunt repair	2 (6.4)	2 (3.0)	2.20	0.33–14.49	0.429
AV shunt usability after intervention, n (%)					

Variable	Arteriovenous (AVF) fistula		Odds ratio or mean difference	95% confidence interval	*p*-value
	AVF failure (n=31) n (%)	AVF success (n=66) n (%)			
Yes	2 (6.4)	62 (94.0)	0.01	0.00–0.02	<0.001
No	29 (93.6)	4 (6.0)	224.80	41.31–1041.00	<0.001
AV shunt location					
Radiocephalic	24 (77.4)	54 (81.8)	0.76	0.28–2.00	0.610
Brachiocephalic	7 (22.6)	12 (18.2)	1.31	0.50–3.56	0.610
Having diabetes mellitus comorbid	15 (48.4)	8 (12.1)	6.80	2.45–19.13	<0.001
Diabetes mellitus duration (years)					
≤3	17 (54.8)	58 (87.9)	0.17	0.06–0.47	<0.001
>3	14 (45.2)	8 (12.1)	5.97	2.12–17.59	<0.001
Having hypertension comorbidities	26 (83.9)	52 (78.8)	1.40	0.44–3.82	0.556
Hypertension duration (years)					
≤6	25 (80.7)	46 (69.7)	1.81	0.68–5.12	0.256
>6	6 (19.3)	20 (30.3)	0.55	0.20–1.48	0.256

The interval between CKD diagnosis and AV shunt placement was significantly associated with AVF outcome (**Table 1**). An interval of <6 months was associated with lower odds of failure (OR: 0.09; 95%CI: 0.04–0.25; *p*<0.001), whereas an interval of >12 months was associated with higher odds of failure (OR: 12.22; 95%CI: 4.18–35.02; *p*<0.001). A duration of AV shunt use of <6 months was associated with substantially higher odds of failure (OR: 464; 95%CI: 59.73–2402; *p*<0.001), while use for >12 months was associated with lower odds of failure (OR: 0.00; 95%CI: 0.00–0.01; *p*<0.001). Failure to achieve AV shunt usability after intervention was also associated with AVF failure (OR: 224.80; 95%CI: 41.31–1041.00; *p*<0.001) (**Table 1**).

Diabetes mellitus was associated with higher odds of AVF failure (OR: 6.80; 95%CI: 2.45–19.13; *p*<0.001), particularly among patients with a diabetes duration of >3 years (OR: 5.97; 95%CI: 2.12–17.59; *p*<0.001) (**Table 1**). In contrast, age, employment status, weight, height, BMI, AV shunt location, hypertension, and hypertension duration were not significantly associated with AVF failure (**Table 1**).

Multivariable analysis of clinical and demographic factors associated with arteriovenous fistula (AVF) failure

Variables with *p*<0.25 in the bivariate analysis were entered into a multivariable logistic regression model. After adjustment for potential confounding factors, previous vascular access type was the only variable independently associated with AVF failure. Compared with the reference category, previous AV shunt use was associated with substantially lower odds of AVF failure (adjusted OR: 0.0046; 95%CI: 0.00002–0.11; *p*=0.008) (**Table 2**).

Age >50 years, female sex, education level, weight, BMI, history of AVF repair, an interval of >12 months between CKD diagnosis and AV shunt placement, subsequent placement of a new AV shunt, and diabetes mellitus were not independently associated with AVF failure after multivariable adjustment (all *p*>0.05) (**Table 2**). Although an interval of >12 months between CKD diagnosis and AV shunt placement showed higher adjusted odds of AVF failure, the association did not reach statistical significance (adjusted OR: 7.58; 95%CI: 0.75–101.50; *p*=0.086) (**Table 2**).

Table 2. Multivariable logistic regression analysis of factors associated with arteriovenous fistula (AVF) failure among patients with stage 5 chronic kidney disease (CKD) receiving hemodialysis

Variable	Arteriovenous (AVF) fistula		aOR	95%CI	*p*-value
	AVF failure (n=31) n (%)	AVF success (n=66) n (%)			
Age (years)					
≤50	19 (61.3)	30 (45.5)	1 (Ref)		
>50	12 (38.7)	36 (54.5)	5.52	0.47–186.50	0.221
Gender					
Male	19 (61.3)	26 (39.4)	1 (Ref)		
Female	12 (38.7)	40 (60.6)	3.32	0.15–220.70	0.501
Education					
Primary school	9 (29)	16 (24.2)	2.05	0.13–69.43	0.622
High school	14 (45.2)	20 (30.3)	0.28	0.01–10.83	0.506
Weight, median (IQR)	58 (50.5–60.5)	59 (50–65.75)	1.06	0.88–1.32	0.551
BMI, median (IQR)	21.48 (20.44–23.14)	22.41 (21.31–26.22)	0.88	0.55–1.29	0.537
Previous access used					
AV shunt	2 (6.5)	62 (94)	0.0046	0.00002–0.11	0.008
Double lumen	20 (64.5)	2 (3)	12.19	0.24–1284	0.230
AVF repaired					
Yes	7 (22.6)	2 (3)	1 (Ref)		
No	24 (77.4)	64 (97)	0.01	0.00–2.02	0.305
Time interval between CKD diagnosis and AV shunt placement					
>12 months	22 (71)	11 (16.6)	7.58	0.75–101.50	0.086
Subsequent intervention after AV shunt failure					
New AV shunt placement	27 (87.2)	63 (95.5)	19.23	0.20–14284	0.266
DM comorbidities					

Variable	Arteriovenous (AVF) fistula		aOR	95%CI	*p*-value
	AVF failure (n=31) n (%)	AVF success (n=66) n (%)			
Yes	15 (48.4)	8 (12.1)	1 (Ref)		
No	16 (51.6)	58 (87.9)	0.27	0.01–6.59	0.418

aOR: adjusted odds ratio; AV: arteriovenous; BMI: body mass index; CI: confidence interval; CKD: chronic kidney disease; DM: diabetes mellitus; IQR: interquartile range; ref: reference category.

Discussion

This retrospective study evaluated demographic and clinical factors associated with AVF failure among patients with stage 5 CKD receiving hemodialysis. Approximately one-third of the patients experienced AVF failure. Although several variables were associated with AVF failure in the bivariate analyses, only previous vascular access type remained statistically significant after multivariable adjustment. Specifically, previous AV shunt use was associated with markedly lower odds of AVF failure.

Previous AV shunt use may indicate more favorable vascular anatomy, successful prior vascular remodeling, planned access management, or earlier engagement with nephrology and vascular services. In contrast, previous use of a double-lumen catheter or manual access may reflect urgent dialysis initiation, delayed AVF planning, limited vascular suitability, or a greater burden of underlying illness. Central venous catheters are associated with higher risks of infection and thrombosis than AVFs, while arteriovenous grafts generally require more frequent interventions and generate higher treatment costs [3,14-16]. A mature AVF provides sustained blood flow for hemodialysis and is associated with fewer access-related complications [17]. Accordingly, early vascular assessment, timely AVF creation, and systematic monitoring of maturation may contribute to better long-term vascular access outcomes [18].

The magnitude of the adjusted association between previous AV shunt use and AVF failure was substantial; however, the estimate should be interpreted cautiously. The very wide confidence interval indicates limited precision, which may reflect the relatively small sample size and sparse observations within several exposure categories. Only two patients in the AVF failure group had previously used an AV shunt, compared with 62 patients in the AVF success group. Such an imbalanced distribution may produce unstable regression estimates and potentially exaggerate the strength of the association. Therefore, the finding should not be interpreted as evidence of a direct protective effect without confirmation in larger prospective studies.

Male sex, education level, history of AVF repair, interval between CKD diagnosis and AV shunt placement, duration of AV shunt use, post-intervention AV shunt usability, and diabetes mellitus were associated with AVF failure in the bivariate analyses. However, these associations were attenuated after multivariable adjustment. This attenuation may reflect confounding, interrelationships among the included variables, or insufficient statistical power rather than the absence of clinically relevant effects. In particular, several variables describing AVF duration, repair, and post-intervention usability are closely related to the course and outcome of vascular access and may therefore be highly correlated. Including them in the same model could produce unstable estimates and obscure independent associations.

Diabetes mellitus was more frequent among patients with AVF failure and was associated with higher odds of failure in the bivariate analysis, but the association was no longer significant after adjustment. Previous studies have similarly linked diabetes mellitus to impaired AVF maturation and failure [9,19]. Chronic hyperglycemia, advanced glycation end-product accumulation, endothelial dysfunction, reduced vascular elasticity, platelet activation, and accelerated atherosclerosis may compromise vascular remodeling and promote thrombosis [20,21]. Nevertheless, the present findings indicate that diabetes mellitus did not independently explain AVF failure after accounting for vascular access history and other covariates. This result should be interpreted cautiously because the study may have lacked sufficient power to detect independent effects of comorbid conditions.

The observed findings are also biologically consistent with the complex process of AVF maturation. Successful maturation requires venous arterialization, outward remodeling of the venous wall, increased blood flow, and preservation of endothelial function [22]. Nitric oxide release and elastin degradation facilitate venous dilatation, while vessel quality, coagulation, inflammation, and local hemodynamic forces influence the remodeling process [23,24]. Conversely, abnormal shear stress and turbulent flow may promote endothelial injury, neointimal hyperplasia, and juxta-anastomotic stenosis, ultimately resulting in access dysfunction or failure. These mechanisms support an individualized approach to vascular access planning that considers vascular anatomy, comorbidities, previous access history, and anticipated dialysis requirements.

The clinical implications of this study extend beyond the selection of access type alone. Vascular access history should be incorporated into preoperative evaluation and access planning, particularly when assessing patients with previous catheter use, unsuccessful access procedures, or prolonged delays between CKD diagnosis and AVF placement. Early referral, vascular mapping, appropriate site selection, careful surgical technique, and structured surveillance of fistula maturation may improve AVF usability and reduce avoidable access failure. However, the present findings do not establish that changing the previous access type would directly modify the risk of subsequent failure.

Some limitations of this study should be acknowledged. The retrospective design precludes causal inference and is susceptible to incomplete documentation and misclassification. The single-center setting and limited sample size restrict generalizability and statistical precision. The number of AVF failure events was relatively small compared with the number of variables considered in the multivariable model, increasing the risk of overfitting. In addition, potentially relevant factors were unavailable, including vessel diameter, preoperative vascular mapping, operator experience, surgical technique, cannulation practices, dialysis duration, medication use, smoking status, inflammatory markers, and adherence to access-care recommendations. Sparse data in several categories also resulted in extreme odds ratios and wide confidence intervals. Prospective multicenter studies with larger populations, standardized AVF definitions, and detailed vascular and procedural assessments are required to validate these findings and develop more reliable prediction models.

Conclusion

This study found that previous vascular access type was independently associated with AVF failure among patients with stage 5 CKD receiving hemodialysis. In particular, previous AV shunt use was associated with markedly lower odds of AVF failure after adjustment for demographic and clinical factors. Other variables identified in the bivariate analysis did not remain statistically significant in the multivariable model. These findings underscore the potential importance of appropriate vascular access selection and management; however, prospective multicenter studies with larger sample sizes are required to confirm the observed association and determine its clinical implications.

Ethics approval

The study protocol has been approved by the Institutional Ethics Committee of Saiful Anwar Hospital Malang, Indonesia, with approval number 0284/KEP-014/XII/08/2021.

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None.

Competing interests

The authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

Declaration of artificial intelligence use

Artificial intelligence tool, Kimi AI, was used for language refinement. Authors confirm that all AI-assisted processes were critically reviewed by the authors to ensure the integrity and reliability of the results. The final decisions and interpretations presented in this article were made solely by the authors.

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References

1. Hamer RA, El Nahas AM. The burden of chronic kidney disease. BMJ 2006;332(7541):563-564.
2. Kovesdy CP. Epidemiology of chronic kidney disease: An update 2022. Kidney Int Suppl (2011) 2022;12(1):7-11.
3. Santoro D, Benedetto F, Mondello P, *et al*. Vascular access for hemodialysis: Current perspectives. Int J Nephrol Renovasc Dis 2014;7(1):281-294.
4. Beristain-Covarrubias N, Perez-Toledo M, Thomas MR, *et al*. Understanding infection-induced thrombosis: Lessons learned from animal models. Front Immunol 2019;10(1):2569.
5. Nenova DD, Yankov YG. Types of vascular access and associated clinical outcomes in dialysis patients. Cureus 2025;17(5):e83691.
6. Venegas-Ramírez J, Hernández-Fuentes GA, Palomares CS, *et al*. Vascular access type and survival outcomes in hemodialysis patients: A seven-year cohort study. Medicina 2025;61(4):584.
7. Yan R, Song A, Zhang C. The pathological mechanisms and therapeutic molecular targets in arteriovenous fistula dysfunction. Int J Mol Sci 2024;25(17):9519.
8. Xia F, Rai V, Agrawal DK. Vascular and perivascular role in the regulation of angiogenesis: Impact on arteriovenous fistula maturation. Arch Intern Med Res 2024;7(4):284-296.
9. Yan Y, Ye D, Yang L, *et al*. A meta-analysis of the association between diabetic patients and AVF failure in dialysis. Ren Fail 2018;40(1):379-383.
10. Liu S, Wang Y, He X, *et al*. Factors affecting suboptimal maturation of autogenous arteriovenous fistula in elderly patients with diabetes: A narrative review. Heliyon 2024;10(15):e35766.
11. Guo S, Wang Y, Zou C, *et al*. Analysis of arteriovenous fistula failure factors and construction of nomogram prediction model in patients with maintenance hemodialysis. Ren Fail 2025;47(1):2500665.
12. Cuschieri S. The STROBE guidelines. Saudi J Anaesth 2019;13(Suppl 1):S31-S34.
13. Venkat Ramanan S, Prabhu RA, Rao IR, *et al*. Outcomes and predictors of failure of arteriovenous fistulae for hemodialysis. Int Urol Nephrol 2022;54(1):185-192.
14. Al-Balas A, Lee T, Young CJ, *et al*. The clinical and economic effect of vascular access selection in patients initiating hemodialysis with a catheter. J Am Soc Nephrol 2017;28(12):3679-3687.
15. Allon M. Vascular access for hemodialysis patients: New data should guide decision making. Clin J Am Soc Nephrol 2019;14(6):954-961.
16. Harms JC, Rangarajan S, Young CJ, *et al*. Outcomes of arteriovenous fistulas and grafts with or without intervention before successful use. J Vasc Surg 2016;64(1):155-162.
17. Woodside KJ, Bell S, Mukhopadhyay P, *et al*. Arteriovenous fistula maturation in prevalent hemodialysis patients in the United States: A national study. Am J Kidney Dis 2018;71(6):793-801.
18. Kosa SD, Al-Jaishi AA, Moist L, *et al*. Preoperative vascular access evaluation for haemodialysis patients. Cochrane Database Syst Rev 2015;2015(9):CD007013.
19. Bahrami-Ahmadi A, Khavanin Zadeh M, Chehrehgosha H, *et al*. Early failure of arteriovenous fistula (AVF): The effect of diabetes and hypertension in a cross-sectional study. Med J Islam Repub Iran 2022;36(1):89.
20. Hussain A. Chronic hyperglycemia and cardiovascular dysfunction: An in-depth exploration of metabolic and cellular pathways in type 2 diabetes mellitus. Cardiovasc Diabetol Endocrinol Rep 2025;11(1):39.
21. Cheraghi M, Karimi A, Sedighi M, *et al*. The interplay between diabetes and atherosclerosis: A review of pathophysiological mechanisms. ARYA Atheroscler 2025;21(5):62-80.

22. Sabiu G, Gallieni M. Pathophysiology of Arteriovenous Fistula Maturation and Nonmaturation. Clin J Am Soc Nephrol 2023;18(1):8-10.
23. Shaalan SH, Auda FM. Evaluation of the vascular remodeling markers elastin, vascular endothelial growth factor A (VEGF-A), vascular endothelial growth factor receptor 2 (VEGFR2), and nitric oxide in patients with varicose veins. Kardiochir Torakochirurgia Pol 2025;22(4):277-284.
24. Diaz JA, Gianesini S, Khalil RA. Glycocalyx disruption, endothelial dysfunction and vascular remodeling as underlying mechanisms and treatment targets of chronic venous disease. Int Angiol 2024;43(6):563-590.