RESEARCH ARTICLE

Risk factors associated with long-term radio-cephalic arteriovenous fistula failure in dialysis patients

Adrian Vasile Mureşan[1,2], Réka Bartus[1,2], Emil-Marian Arbănași[1,2,3,4], Eliza-Mihaela Arbănaşi[3,4], Alexandru Ludovic Szanto[2], Elena Florea[2], Cătălin Mircea Coşarcă[2], Marius Mihai Harpa[5,6], Ioan Hosu[7*], Claudiu Constantin Ciucanu[1,2,3], Nicolae Alexandru Lazar[2], Ionela Georgiana Bodiu[2], Eliza Russu[1,2]

1. Department of Vascular Surgery, George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Targu Mures, Romania
2. Clinic of Vascular Surgery, Mures County Emergency Hospital, Targu Mures, Romania
3. Doctoral School of Medicine and Pharmacy, George Emil Palade University of Medicine, Pharmacy, Science and Technology of Targu Mures, Romania
4. Regenerative Medicine Laboratory, Centre for Advanced Medical and Pharmaceutical Research, George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Targu Mures, Romania
5. Emergency Institute for Cardiovascular Diseases and Transplantation Targu Mures, Romania
6. Department of Surgery, George Emil Palade University of Medicine, Pharmacy, Science and Technology of Targu Mures, Romania
7. Department of Nephrology, Mures County Emergency Hospital, Targu Mures, Romania

Objective: The aim of this study is to analyze the risk factors associated with long-term radio-cephalic arteriovenous fistula failure in dialysis patients.

Methods: This retrospective observational study enrolled 81 patients diagnosed with end-stage kidney disease requiring arteriovenous fistula. Patients were categorized into two groups based on the long-term permeability of vascular access. The hospital's electronic database was used to collect demographic data, risk factors, comorbidities, pre-operative laboratory data, and pre-operative vascular mapping characteristics.

Results: Among the patients with arteriovenous fistula failure, we observed a lower incidence of men (p=0.009), a higher incidence of diabetes mellitus (p=0.036), and a higher incidence of active smoking (p=0.009). At ROC-curve analysis we identified an optimal cut-off value of 128.2 for glucose (AUC: 0.715, 66.7% Sensitivity, and 78.1% Specificity), 1.17 for leukocyte glucose index (AUC: 0.692, 60.0% Sensitivity, and 81.2% Specificity), and 7.33 for interleukin-6 (AUC: 0.925, 90.0% Sensitivity, and 84.6% Specificity). In Kaplan-Meier survival curve analysis, there was a higher incidence of arteriovenous fistula failure among females (p=0.033), smokers (p<0.001), and patients undergoing hemodialysis via a central venous catheter at the time of admission (p=0.047). Cox-regression analysis indicates that female sex (HR: 3.43, p=0.033) and active smoking (HR: 5.02, p=0.002) are predictors of vascular access dysfunction. Additionally, elevated values of glucose (HR: 1.89, p=0.004), Interleukin-6 (HR: 2.78, p=0.001), and leukocyte glucose index (HR: 1.95, p=0.008) are associated with arteriovenous fistula failure.

Conclusions: In conclusion, female sex, active smoking, high baseline glucose levels, Interleukin-6, and leukocyte glucose index are linked to long-term failure of arteriovenous fistula failure.

Keywords: leukocyte glucose index, vascular surgery, arteriovenous fistula, dialysis, interleukin-6

Introduction

Autologous arteriovenous fistula (AVF) is the recommended vascular access for dialysis according to the guidelines of the European Society of Vascular Surgery (ESVS) in end-stage kidney disease (ESKD) patients [1]. Also, AVF has better long-term patency compared to arteriovenous fistula graft (AVG) [1–3] and a lower mortality rate compared to a central venous catheter (CVC) [4]. However, the long-term functionality of AVF is affected by factors such as the site of surgical creation, the quality of the venous wall, systemic inflammation, and the presence of risk factors like diabetes, smoking, and cardiac comorbidities [1,4–7].

In a recent study published by Muresan et al. [4], the authors observed a significantly higher incidence of tobacco (66.67% vs 39.03%, p<0.0001) and elevated values of inflammatory markers (for all p<0.0001) in patients with ESKD whit poor outcome at 30 days. The same authors confirmed the aforementioned results in a study where they monitored AVF maturation failure within a cohort of 125 patients [5]. More recently, Muresan et al. [7] demonstrated a correlation between elevated leukocyte glucose index (LGI) values (HR:1.48, 95%CI 1.14-1.92, p=0.003) and long-term vascular access failure.

The primary objective of vascular access for dialysis is to establish a distal AVF in the non-dominant limb, between the radial artery and the cephalic vein (RC-AVF), if the vessel meets the quality criteria [1,5,6,8]. In the long term, RC-AVF presents a lower risk of steal syndrome [1,9,10] and aneurysmal development [1,9,10] compared to brachio-cephalic AVF (BC-AVF), but with a higher rate of maturation failure and primary and secondary pa-

* Correspondence to: Ioan Hosu
E-mail: ioan.hosu@umfst.ro

tency [1,11–13]. Also, the presence of a dialysis CVC has a negative impact on the long-term functionality of the AVF [1,14], regardless of the type of AVF performed [14]. According to literature studies, the maturation failure rate for RC-AVF is between 5-46%, and the secondary patency rate at 1 year is between 42-83% [1,15–18].

The primary aim of this study is to analyze the risk factors associated with long-term RC-AVF failure in dialysis patients. Additionally, we will investigate the role of inflammatory markers in AVF dysfunction and the impact of pre-operative vascular mapping.

Methods
Study Design
This retrospective and observational study includes all patients with ESKD who were hospitalized in the Vascular Surgery Clinic at Târgu Mureș County Clinical Hospital between January 2019 and August 2023 for an RC-AVF surgical creation. Patients who were hospitalized for existing AVF dysfunction, those with a septic state, autoimmune diseases, and those for whom information was not available in the hospital's electronic database were excluded. The patients were divided into two groups based on long-term AVF outcomes: "Functional AVF" and "AVF Failure". This study was approved by the Medical Ethics Committee for the Clinical Study of Medicines of the County Emergency Clinical Hospital Târgu Mureș, decision number 21407/09.10.2023.

Data Collection
The hospital's electronic database was used to collect demographic data, risk factors, comorbidities, pre-operative laboratory data, and pre-operative vascular mapping characteristics. We monitored for the presence of cardiovascular pathologies, diabetes mellitus, chronic obstructive pulmonary disease (COPD), obesity, and active smoking. Additionally, we recorded pre-operative laboratory analyses and calculated systemic inflammatory markers such as LGI [7], neutrophil to lymphocyte ratio (NLR) [4–6,19], platelets to lymphocyte ratio (PLR) [4–6], monocyte to lymphocyte ratio (MLR) [4,20], and derived neutrophil to lymphocyte ratio (dNLR) [19] (Table I). Additionally, the Interleukin-6 (IL-6) values were available only for 42 patients. During pre-operative vascular mapping, we recorded the diameter of the radial artery, the cephalic vein, and the depth of the cephalic vein. We also noted whether the RC-AVF was performed in the non-dominant limb or if the patients were undergoing dialysis at the time of admis-

sion. All patients in the study were either in outpatient settings or were hospitalized overnight for cost-effectiveness benefit [21].

Study Outcomes
The primary outcome of the study was to identify the risk factors linked to the long-term failure of RC-AVF. Additionally, we examined the influence of systemic inflammatory markers and the impact of dialysis via CVC at the time of admission on the dysfunction of dialysis vascular access. AVF permeability data was collected from the chronic dialysis centers where the patients are receiving treatment.

Statistical analysis
For the statistical analysis, we are using SPSS for Mac OS version 29.0.2.0 (SPSS, Inc. in Chicago, IL, USA). The mean values and standard deviations were used to present the laboratory data and pre-operative vascular mapping characteristics. We compared characteristics between groups using chi-square tests for dichotomous variables. Additionally, we used Mann-Whitney and Student's t-tests to assess differences between continuous variables. ROC curve analysis was utilized to determine the best cut-off values for glucose, interleukin-6, and LGI in relation to the risk of AVF failure.

We conducted multivariate Cox proportional hazard analyses to find independent predictors of RC-AVF failure in dialysis patients. Additionally, the hazard ratio (HR) was expressed per 1 standard deviation increase in the baseline for all analyzed laboratory data. We used Kaplan-Meier curves to show the crude association between demographic data, diabetes mellitus, active smoking, and CVC hemodialysis at the time of admission and long-term RC-AVF failure. To compare the curves, we used the Log Rank test. All tests were two-tailed, and a p-value less than 0.05 was considered statistically significant.

Results
In this study, we included 81 patients with RC-AVF who met all the criteria. The average age of the patients was 60.66±14.30, with 44 being men (54.32%) and 37 being women (45.68%). Among the most common comorbidities, according to the data presented in Table II, we found that 81.48% of patients had hypertension, 55.56% had ischemic heart disease, and 39.51% had diabetes mellitus. At the time of admission, 39 patients were not yet undergoing hemodialysis, and 13 patients had undergone RC-AVF in the dominant upper limb. In terms of pre-opera-

Table I. Formulas used for the systemic inflammatory biomarkers analyzed in this study.

Inflammatory Biomarkers	Formulas
Leukocyte glucose index (LGI)	(WBC count * Glucose level) / 1000
Neutrophil to Lymphocyte ratio (NLR)	Neutrophils count / Lymphocytes count
Platelets to Lymphocyte ratio (PLR)	Platelets count / Lymphocytes count
Monocyte to Lymphocyte ratio (MLR)	Monocytes count / Lymphocytes count
Derived Neutrophil to Lymphocyte ratio (dNLR)	Neutrophils count / (WBC count - Neutrophils count)

tive vascular mapping, we found that the average diameter of the radial artery was 2.94±0.86, the average diameter of the cephalic vein was 2.95±0.65, and the average depth of the cephalic vein was 2.56±0.78.

Furthermore, among the patients experiencing AVF failure, a significantly lower prevalence of males was noted (25.00% vs 61.54%, p=0.009). Additionally, there was a notably higher prevalence of diabetes mellitus (62.50% vs 33.85%, p=0.036) and active smoking (37.50% vs 10.77%, p=0.009) (Table II). With respect to the laboratory data, we observed elevated levels of glucose (p=0.010), LGI (p=0.021), and interleukin-6 (p<0.001) in patients exhibiting vascular access dysfunction. While we did not observe significant statistical differences in the pre-operative vascular mapping determinations, we did note a higher incidence of pre-dialysis patients among those with functional RC-AVF (Table II).

In the ROC analysis, we found a positive association between the glucose level at admission, the pre-operative values of LGI and IL-6, and long-term RC-AVF Failure (Figure 1). We identified an optimal cut-off value of 128.2 for glucose (Area under curve (AUC): 0.715, 66.7% Sensitivity, and 78.1% Specificity), 1.17 for LGI (AUC: 0.692, 60.0% Sensitivity, and 81.2% Specificity), and 7.33 for IL-6 (AUC: 0.925, 90.0% Sensitivity, and 84.6% Specificity) (Figure 1). The findings indicate that both glucose levels and inflammatory markers represent statistically significant and clinically actionable thresholds for identifying patients at an elevated risk of AVF failure.

Furthermore, in Kaplan-Meier survival curve analysis, there was a higher incidence of AVF failure among female patients (p=0.033), smokers (p<0.001), and patients undergoing hemodialysis via a CVC at the time of admission (p=0.047) (Figure 2).

We conducted a cox-regression analysis to determine which factors predict long-term RC-AVF failure. The analysis revealed that female sex (HR: 3.43, p=0.033) and active smoking (HR: 5.02, p=0.002) are predictors of vas-

Table II. Demographic data, associated comorbidities, and laboratory data of the enrolled patients.

Variables	All Patients n=81	Functional AVF n=65	AVF Failure n=16	p value
Age mean ± SD	60.66±14.30	60.69±14.54	60.56±13.71	0.973
Male no. (%)	44 (54.32%)	40 (61.54%)	4 (25.00%)	0.009
Comorbidities and Risk factors, no. (%)				
Hypertension	66 (81.48%)	55 (84.62%)	11 (68.75%)	0.143
Ischemic Heart Disease	45 (55.56%)	36 (55.38%)	9 (56.25%)	0.950
Atrial Fibrillation	6 (7.41%)	3 (4.62%)	3 (18.75%)	0.053
Cardiovascular events	4 (4.94%)	3 (4.62%)	1 (6.25%)	0.787
Cerebrovascular events	6 (7.41%)	3 (4.62%)	3 (18.75%)	0.053
Diabetes Mellitus	32 (39.51%)	22 (33.85%)	10 (62.50%)	0.036
Chronic Obstructive Pulmonary Disease	7 (8.64%)	5 (7.69%)	2 (12.50%)	0.540
Peripheral Arterial Disease	9 (11.11%)	6 (9.23%)	3 (18.75%)	0.278
Obesity	17 (20.99%)	14 (21.54%)	3 (18.75%)	0.806
Active Smoking	13 (16.05%)	7 (10.77%)	6 (37.50%)	0.009
Laboratory data, mean ± SD				
WBC	8.36±2.37	8.33±2.44	8.50±2.12	0.534
BUN (mg/dL)	137.94±56.42	139.32±58.05	131.71±49.87	0.658
Creatinine (mg/dL)	6.58±2.65	6.62±2.75	6.41±2.23	0.912
Eosinophils x10³/uL	0.27±0.26	0.29±0.28	0.18±0.11	0.204
Potassium (mmol/L)	5.26±0.86	5.19±0.87	5.57±0.81	0.109
Sodium (mmol/L)	139.34±3.38	139.44±3.55	138.96±2.68	0.535
Glucose (mg/dL)	118.29±36.64	112.45±32.42	143.2±43.93	0.010
Hemoglobin g/dL	10.26±1.99	10.29±2.02	10.10±1.92	0.772
Hematocrit %	31.41±6.21	31.58±6.40	30.66±5.38	0.753
Neutrophils x10³/uL	5.69±1.87	5.71±1.87	5.66±1.94	0.995
Lymphocytes x10³/uL	1.64±0.71	1.65±0.69	1.58±0.85	0.575
Monocyte x10³/uL	0.64±0.25	0.65±0.26	0.64±0.22	0.671
PLT x10³/uL	242.35±79.55	236.51±76.33	267.72±90.69	0.175
LGI	0.99±0.42	0.93±0.37	1.24±0.53	0.021
Interleukin-6 (pg/mL)*	6.54±2.48	5.68±2.01	9.28±1.79	<0.001
NLR	4.07±2.27	3.97±2.19	4.50±2.63	0.662
PLR	170.91±89.41	159.59±62.35	219.95±155.46	0.158
MLR	0.45±0.21	0.44±0.20	0.48±0.25	0.522
dNLR	2.38±1.09	2.36±1.05	2.48±1.29	0.848
Pre-operative Vascular Mapping, mean ± SD				
Radial Artery Diameter	2.94±0.86	2.97±0.81	2.74±1.15	0.119
Cephalic Vein Diameter	2.95±0.65	3.01±0.68	2.65±0.29	0.151
Cephalic Vein Depth	2.56±0.78	2.54±0.74	2.66±1.12	0.722
Dominant Upper Limb, no. (%)	13 (16.05%)	9 (13.85%)	4 (25.00%)	0.276
Pre-Dialysis, no. (%)	39 (48.15%)	35 (53.85%)	4 (25.00%)	0.018

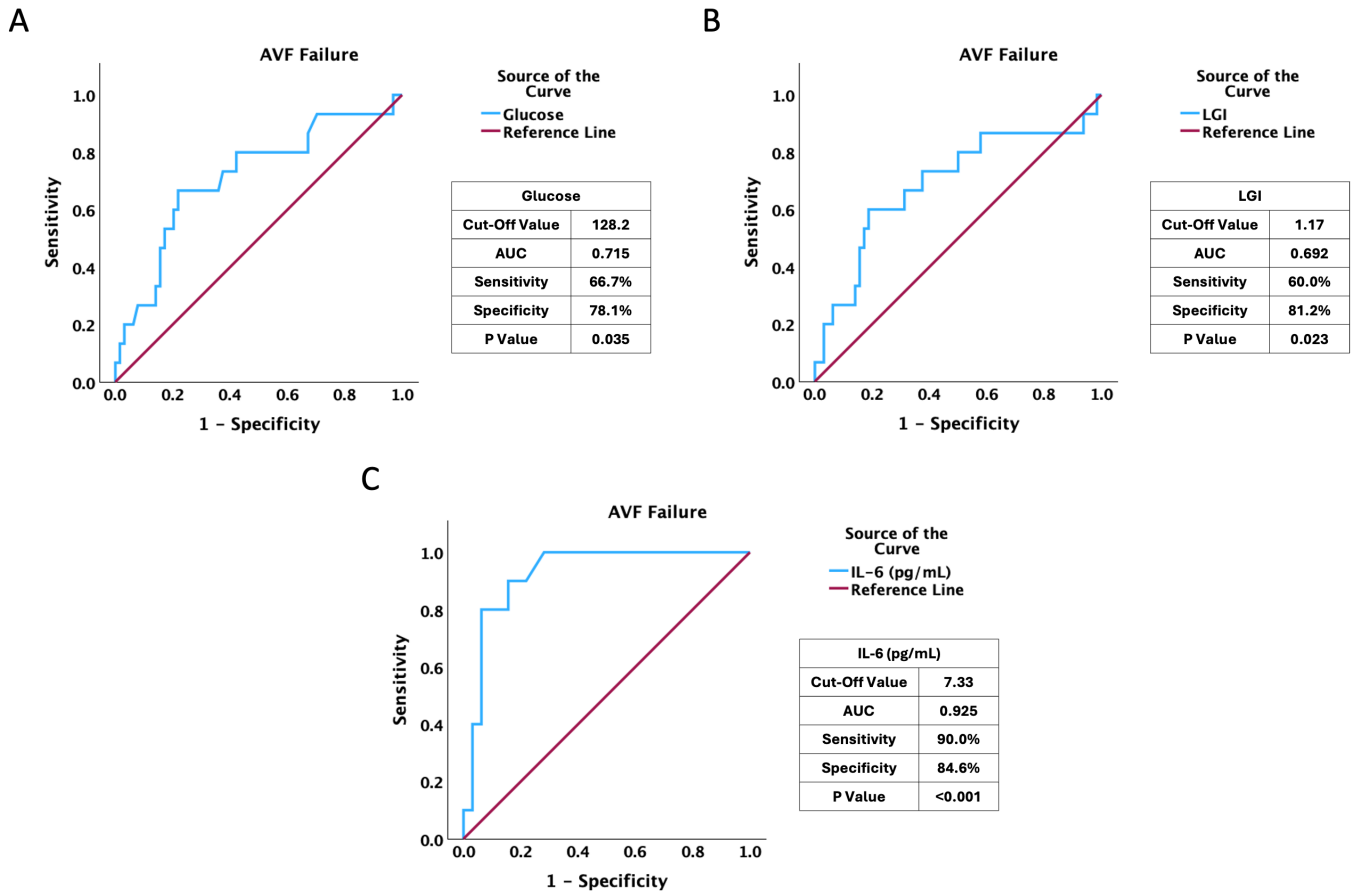* Value of Interleukin-6 is available only for a group of 42 patients from entire cohort.

Fig. 1. ROC analysis of long-term RC-AVF failure in relation to: Glucose levels (A), LGI (B), and IL-6 (C).
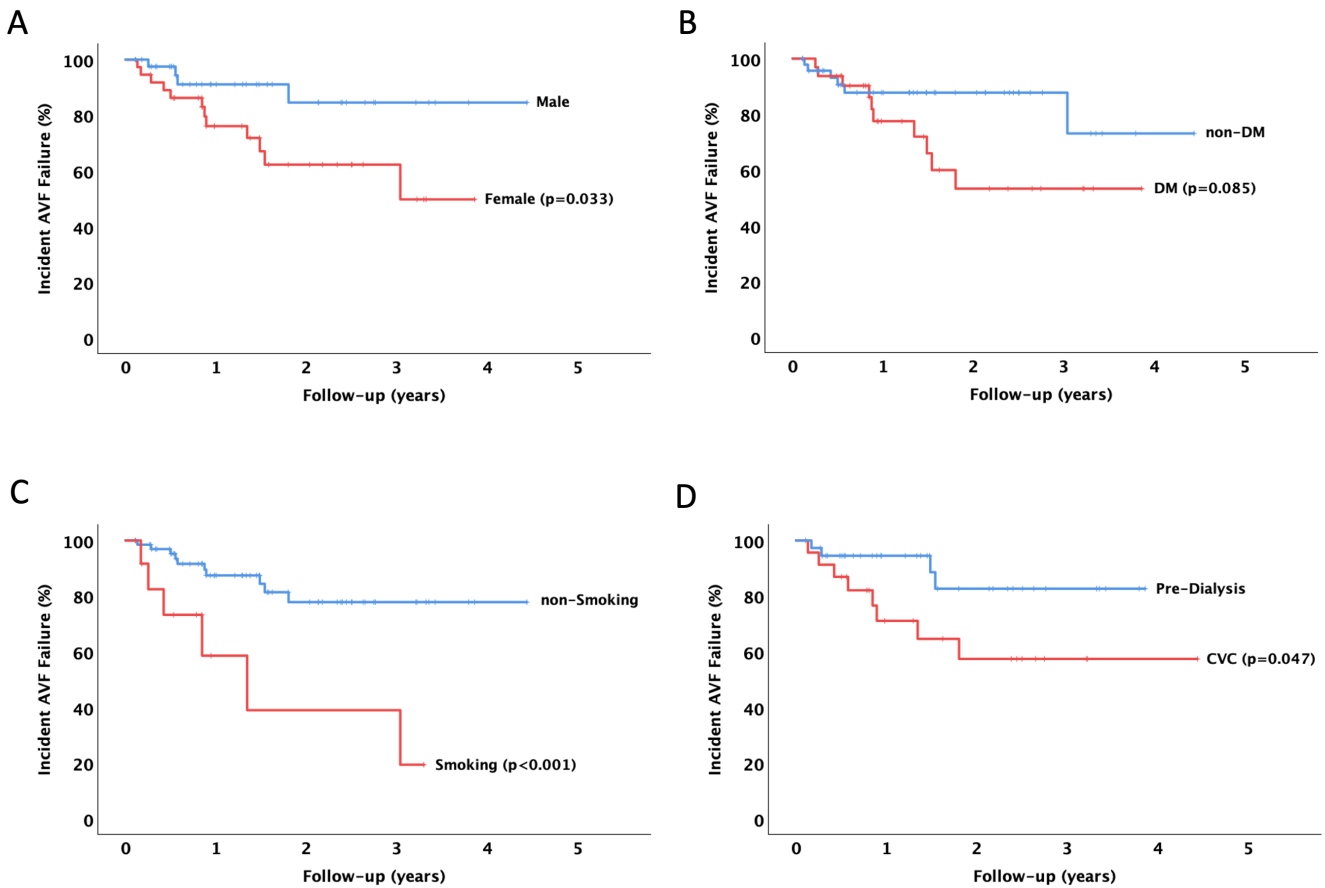

Fig. 2. Kaplan-Meier survival curves for the incidence of AVF failure in the entire cohort by: sex (A), diabetes mellitus (B), smoking status (C), and hemodialysis via a CVC at the time of admission (D). The p-value was calculated using an unadjusted log-rank test.

cular access dysfunction (Table III). Additionally, elevated basal values of glucose (HR: 1.89, p=0.004), IL-6 (HR: 2.78, p=0.001), and LGI (HR: 1.95, p=0.008) are associated with RC-AVF failure. Our findings emphasize the importance of systemic inflammation and metabolic dysfunction in the long-term failure of RC-AVF.

Discussions

The primary finding of this study is that females, active smoking, and high baseline levels of glucose, IL-6, and LGI are linked to long-term failure of RC-AVF. Moreover, patients experiencing vascular access dysfunction for dialysis have a high prevalence of diabetes mellitus and are often undergoing hemodialysis with a CVC at the time of AVF creation.

Similar to the results of our study, Miller et al. [22], Peterson et al. [23], and See et al. [24] observed that female patients have an increased risk of maturation failure and early and long-term AVF dysfunction. Another well-known risk factor of AVF failure is diabetes mellitus, and this was demonstrated by us in previously published studies [5–7], as well as in recent studies published in the literature [25–27]. In a meta-analysis by Yan et al. [25], the authors showed that the incidence of AVF failure is higher in diabetic patients compared to non-diabetic individuals (OR: 1.682, p<0.001). Additionally, Afsar and Elsurer [26] demonstrated that poor glycemic control (OR: 2.785, p=0.002) is the basis of the link between the presence of diabetes and AVF dysfunction. Smoking is also associated with unfavorable outcomes for both AVF [27,28] and ESKD patients [4].

Regarding inflammatory biomarkers, IL-6 has been the most frequently analyzed in AVF failure, while LGI is the most recently proposed biomarker. Kaller et al. [6] found that basal levels of IL-6 are increased in patients with intimal hyperplasia in the venous wall (p=0.0001) and are positively associated with neovascularization in the neointima (r=0.611, p<0.001). Baek et al. [29] observed that patients with baseline IL-6 values in tertile 3 (T3) have a three times higher risk of AVF dysfunction at one year (HR: 3.06, p=0.015). Marrone et al. [30] also demonstrated that local activation of IL-6 signaling is associated with AVF stenosis. In a recent study by Mureşan et al. [7], high pre-operative LGI values were associated with AVF dysfunction independent of sex, age, cardiovascular risk factors, and pre-operative vascular mapping characteristics.

In the current study, we identified an increased risk of AVF failure in patients undergoing hemodialysis on CVC at admission, but in the cox-regression analysis, the statistical significance was not maintained (p=0.062). Nevertheless, a study by Ravani et al. [31] showed that the use of CVC at the start of dialysis (p=0.0005) and the time from surgical creation to maturation (p=0.0007) are linked to an increased incidence of primary patency failure of AVF in a cohort of 414 patients.

Although the ESVS guidelines recommend the RC-AVF as the primary intention, this specific type of AVF is associated with elevated failure rates in terms of maturation and long-term patency [1]. Consequently, various techniques have been developed to enhance the patency of RC-AVF, such as the no-touch technique (NTT) and the modified no-touch technique (MNTT) [32]. A systematic review published by Bhojani et al. [33] demonstrated that nonconventional techniques, including NTT and MNTT, positively influence the long-term survival rates of RC-AVF. Furthermore, Inagaki et al. [34] introduced the resistance index (RI) as a novel prognostic tool for predicting AVF failure and established that a higher postoperative RI value is correlated with vascular access dysfunction. Regarding preoperative vascular mapping, Jiang et al. [35] illustrated that the diameter disparity between the radial artery and cephalic veins positively correlates with the primary patency of RC-AVF.

The current study has certain limitations that should be mentioned. Firstly, we only included patients with RC-AVF, so our findings may not apply to other types of AVF. Secondly, this was a retrospective study conducted at a single center with a small group of patients. We suggest that future research should involve larger, multicenter, prospective studies to provide more reliable conclusions. Additionally, all patients received surgical AVF, and we did not include those with percutaneous AVF. Lastly, AVF dysfunction was assessed by contacting chronic dialysis centers, and we were unable to evaluate the risk of aneurysmal development of the AVF or the extent of intimal hyperplasia using doppler ultrasound. We recommend periodic patient evaluations in the future to assess the risk of stenosis and aneurysmal development of the AVF.

Table III. Association between demographic data, comorbidities, preoperative laboratory parameters, and long-term outcomes of RC-AVF failure.

Variables	RC-AVF Failure		
	HR	95% CI	p value
Female	3.43	1.10-10.64	0.033
Diabetes Mellitus	2.51	0.91-6.93	0.075
Active Smoking	5.02	1.79-14.02	0.002
Pre-Dialysis	0.32	0.09-1.06	0.062
Glucose	1.89#	1.22-2.93	0.004
IL-6*	2.78#	1.51-5.14	0.001
LGI	1.95#	1.19-3.21	0.008

HR expressed per 1 SD increase in baseline; * The value of IL-6 is available only for a group of 42 patients from the entire cohort.

Conclusion

In conclusion, female sex, active smoking, and high baseline levels of glucose, IL-6, and LGI are linked to long-term failure of RC-AVF. Moreover, patients experiencing vascular access dysfunction for dialysis have a high prevalence of diabetes mellitus and are often undergoing hemodialysis with a CVC at the time of AVF creation.

Authors' contribution

AVM (Conceptualization; Methodology; Visualization; Writing – original draft; Supervision; Validation)

BR (Conceptualization; Formal analysis; Investigation; Resources)

Emil-Marian A (Conceptualization; Methodology; Formal analysis; Software; Writing – original draft; Validation)

Eliza-Mihaela A (Writing – review & editing; Formal Analysis; Validation)

ALS (Formal analysis; Investigation; Resources; Validation)

EF (Data curation; Investigation; Resources; Validation)

CMC (Investigation; Resources; Validation)

MMH (Formal analysis; Investigation; Validation)

IH (Data curation; Formal analysis; Supervision; Validation)

CCC (Formal analysis; Software; Data curation; Validation)

NAL (Data curation; Investigation; Validation)

IGB (Data curation; Investigation; Validation)

ER (Project administration; Methodology; Validation; Visualization; Supervision)

Conflict of interest

None to declare.

Acknowledgments

References

1. Schmidli J, Widmer MK, Basile C, De Donato G, Gallieni M, Gibbons CP, et al. Editor's Choice – Vascular Access: 2018 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg. 2018 Jun;55(6):757–818.

2. Hajibandeh S, Burton H, Gleed P, Hajibandeh S, Wilmink T. Impact of arteriovenous fistulas versus arteriovenous grafts on vascular access performance in haemodialysis patients: A systematic review and meta-analysis. Vascular. 2022 Dec;30(6):1021–33.

3. Li J, Lu H, Xie Z, Li Q, Shi H. Outcomes of arteriovenous graft vs. fistula for haemodialysis access in the elderly: A systematic review and meta-analysis. Exp Ther Med. 2023 Aug 1;26(2):1–9.

4. Mureşan AV, Russu E, Arbănaşi EM, Kaller R, Hosu I, Arbănaşi EM, et al. The Predictive Value of NLR, MLR, and PLR in the Outcome of End-Stage Kidney Disease Patients. Biomedicines. 2022 Jun;10(6):1272.

5. Kaller R, Arbănaşi EM, Mureşan AV, Voidăzan S, Arbănaşi EM, Horváth E, et al. The Predictive Value of Systemic Inflammatory Markers, the Prognostic Nutritional Index, and Measured Vessels' Diameters in Arteriovenous Fistula Maturation Failure. Life. 2022 Sep;12(9):1447.

6. Kaller R, Russu E, Arbănaşi EM, Mureşan AV, Jakab M, Ciucanu CC, et al. Intimal CD31-Positive Relative Surfaces Are Associated with Systemic Inflammatory Markers and Maturation of Arteriovenous Fistula in Dialysis Patients. J Clin Med. 2023 Jan;12(13):4419.

7. Mureşan AV, Florea E, Arbănaşi EM, Bartus R, Arbănaşi EM, Ion AP, et al. Elevated Leukocyte Glucose Index Is Associated with Long-Term Arteriovenous Fistula Failure in Dialysis Patients. J Clin Med. 2024 Jan;13(7):2037.

8. Weigang T, Wei X, Lifeng G, Jingkui L, Yani L, Huaqin J, et al. A meta-analysis of traditional and functional end-to-side anastomosis in radiocephalic fistula for dialysis access. Int Urol Nephrol. 2021 Jul;53(7):1373–82.

9. Mishra B. Comparison of distal radiocephalic fistula vs proximal radiocephalic fistula. J Fam Med Prim Care. 2021 Jan;10(1):132–7.

10. Güven C, Uludağ Ö, Güven C, Uludağ Ö. Proximal Arteriovenous Fistulas in Hemodialysis Patients: Advantages and Disadvantages. Cureus [Internet]. 2020 Nov 23 [cited 2024 Oct 7];12(11). Available from: https://www.cureus.com/articles/44821-proximal-arteriovenous-fistulas-in-hemodialysis-patients-advantages-and-disadvantages

11. Kim SM, Park PJ, Kim HK. Comparison between radiocephalic and brachiocephalic arteriovenous fistula in octogenarians: A retrospective single center study. J Vasc Access. 2024 May;25(3):849–53.

12. Sabah MN, Ahmed SP, Khan MSU, Hasan R, Hossain MF, Fatma MN. A Comparative Study between Radiocephalic and Brachiocephalic Arteriovenous Fistula in End Stage Renal Disease. Cardiovasc J. 2021 Sep 15;14(1):44–9.

13. Weale AR, Bevis P, Neary WD, Boyes S, Morgan JD, Lear PA, et al. Radiocephalic and brachiocephalic arteriovenous fistula outcomes in the elderly. J Vasc Surg. 2008 Jan;47(1):144–50.

14. Plauche L, Farber A, King EG, Levin SR, Cheng TW, Rybin D, et al. Brachiocephalic and Radiocephalic Arteriovenous Fistulas in Patients with Tunneled Dialysis Catheters Have Similar Outcomes. Ann Vasc Surg. 2023 Oct;96:98–103.

15. Huijbregts HJT, Bots ML, Wittens CHA, Schrama YC, Moll FL, Blankestijn PJ, et al. Hemodialysis arteriovenous fistula patency revisited: results of a prospective, multicenter initiative. Clin J Am Soc Nephrol CJASN. 2008 May;3(3):714–9.

16. Silva MB, Hobson RW, Pappas PJ, Jamil Z, Araki CT, Goldberg MC, et al. A strategy for increasing use of autogenous hemodialysis access procedures: impact of preoperative noninvasive evaluation. J Vasc Surg. 1998 Feb;27(2):302–7; discussion 307-308.

17. Allon M, Lockhart ME, Lilly RZ, Gallichio MH, Young CJ, Barker J, et al. Effect of preoperative sonographic mapping on vascular access outcomes in hemodialysis patients. Kidney Int. 2001 Nov 1;60(5):2013–20.

18. Ravani P, Marcelli D, Malberti F. Vascular access surgery managed by renal physicians: the choice of native arteriovenous fistulas for hemodialysis. Am J Kidney Dis Off J Natl Kidney Found. 2002 Dec;40(6):1264–76.

19. Hu H, Yao X, Xie X, Wu X, Zheng C, Xia W, et al. Prognostic value of preoperative NLR, dNLR, PLR and CRP in surgical renal cell carcinoma patients. World J Urol. 2017 Feb;35(2):261–70.

20. Hu S, Wang D, Ma T, Yuan F, Zhang Y, Gao X, et al. Association between Preoperative Monocyte-to-Lymphocyte Ratio and Late Arteriovenous Fistula Dysfunction in Hemodialysis Patients: A Cohort Study. Am J Nephrol. 2021;52(10–11):854–60.

21. Russu E, Munteanu AC, Arbănaşi EM, Szanto LA, Bartus R, Florea E, et al. Out-Patient versus In-Patient Arteriovenous Fistula Creation for Dialysis: Assessing Cost-Effectiveness Alongside Clinical Implications. Healthcare. 2024 Jan;12(11):1102.

22. Miller CD, Robbin ML, Allon M. Gender differences in outcomes of arteriovenous fistulas in hemodialysis patients. Kidney Int. 2003 Jan;63(1):346–52.

23. Wj P, J B, M A. Disparities in fistula maturation persist despite preoperative vascular mapping. Clin J Am Soc Nephrol CJASN [Internet]. 2008 Mar [cited 2024 Oct 7];3(2). Available from: https://pubmed.ncbi.nlm.nih.gov/18235150/

24. See YP, Cho Y, Pascoe EM, Cass A, Irish A, Voss D, et al. Predictors of Arteriovenous Fistula Failure: A Post Hoc Analysis of the FAVOURED Study. Kidney360. 2020 Nov 25;1(11):1259–69.

25. Yan Y, Ye D, Yang L, Ye W, Zhan D, Zhang L, et al. A meta-analysis of the association between diabetic patients and AVF failure in dialysis. Ren Fail. 2018 Nov;40(1):379–83.

26. Afsar B, Elsurer R. The primary arteriovenous fistula failure—a comparison between diabetic and non-diabetic patients: glycemic control matters. Int

Urol Nephrol. 2012 Apr 1;44(2):575–81.

27. Ozdemir FN, Akcay A, Bilgic A, Akgul A, Arat Z, Haberal M. Effects of smoking and blood eosinophil count on the development of arteriovenous fistulae thrombosis in hemodialysis patients. Transplant Proc. 2005 Sep;37(7):2918–21.

28. Kler A, Khambalia H, Pondor Z, Donne R, Giuffrida G, Augustine T, et al. Smoking is associated with a higher complication and failure rate in arteriovenous grafts for haemodialysis: A multi-centre experience. J Vasc Access. 2023 Jul;24(4):747–53.

29. Baek J, Lee H, Yang T, Lee SY, Kim YG, Kim JS, et al. Plasma Interleukin-6 Level Predicts the Risk of Arteriovenous Fistula Dysfunction in Patients Undergoing Maintenance Hemodialysis. J Pers Med. 2023 Jan;13(1):151.

30. Marrone D, Pertosa G, Simone S, Loverre A, Capobianco C, Cifarelli M, et al. Local Activation of Interleukin 6 Signaling Is Associated With Arteriovenous Fistula Stenosis in Hemodialysis Patients. Am J Kidney Dis. 2007 May 1;49(5):664–73.

31. Ravani P, Brunori G, Mandolfo S, Cancarini G, Imbasciati E, Marcelli D, et al. Cardiovascular comorbidity and late referral impact arteriovenous fistula survival: a prospective multicenter study. J Am Soc Nephrol JASN. 2004 Jan;15(1):204–9.

32. Hou G, Fu M, Wang X, Liu Z, Zhang Y, Zhu D, et al. Modified no-touch technique for radio-cephalic arteriovenous fistula increases primary patency and decreases juxta-anastomotic stenosis. J Vasc Access. 2024 May;25(3):904–13.

33. Bhojani MF, Malik J, Mumtaz A, Sophie Z, Waseem S. Beyond Conventional: A Systematic Review of Non-Conventional Techniques for Radio-Cephalic Arteriovenous Fistula. Ann Vasc Surg. 2024 Aug 7;S0890-5096(24)00488-6.

34. Inagaki K, Onogi C, Iimuro K, Suzuki A, Furusawa S, Tsuji M, et al. Early postoperative resistance index can predict radiocephalic arteriovenous fistula failure. J Vasc Access. 2024 Nov 1;11297298241295267.

35. Jiang Y, Huang X, Shan Y, Chen L, Huang H, Jiang L, et al. The difference in diameter between radial artery and cephalic vein correlates with primary patency of radio-cephalic arteriovenous fistula. J Vasc Access. 2024 May;25(3):914–21.