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The effect of hematological tests on fistula maturation in end-stage renal disease patients with radiocephalic arteriovenous fistula

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ABSTRACT

Aims: Arteriovenous fistula (AVF) is the most commonly used vascular access route for hemodialysis (HD) in patients with end-stage renal disease. The most significant cause of AVF dysfunction is stenosis and post-stenotic thrombosis. Fistula stenosis arises from neointimal hyperplasia and various inflammatory factors. Several inflammatory markers have been studied in relation to AVF loss. This study aims to provide a comprehensive perspective on this globally prevalent health issue by examining the association between the continuity of surgically created AVFs and the patients' clinical factors, inflammatory markers, and biochemical parameters.

Methods: A total of 146 patients were included in the study. All patients underwent preoperative examination of the upper extremity arterial and venous systems to confirm normal circulation. Patients with suitable arterial and venous structures underwent radiocephalic AVF creation at the wrist level. AVFs that achieved adequate flow and allowed for HD were considered matured.

Results: Of the patients, 83 were male and 63 were female. The mean age of the patient group was 58.9±11.41 years, with a minimum age of 30 and a maximum of 77 years. Male sex, low body-mass index (BMI), antiplatelet use, and low neutrophil-to-lymphocyte ratio (NLR) and red cell distribution width (RDW) values were positively associated with AVF maturation. However, age, smoking status, type of anesthesia, diabetes, hypertension, and other blood parameters were not significantly associated with AVF maturation.

Conclusion: Our study demonstrated that low maturation rates of AVFs were associated with high NLR and RDW values. In addition, antiplatelet use, male sex, and low BMI were found to be associated with AVF maturation.

Keywords: Arteriovenous fistula, fistula maturation, inflammation

INTRODUCTION

Due to declining birth rates and increased life expectancy, especially in developed societies, the elderly population and, consequently, the incidence of end-stage renal disease (ESRD) are rapidly increasing. The most commonly used treatment method for these patients is hemodialysis (HD) via an arteriovenous fistula (AVF).[1] The Brescia-Cimino AVF is considered the gold standard for primary vascular access.[2] Complications in vascular access represent a significant cause of prolonged hospitalization, morbidity, and mortality in HD patients. The most common cause of dysfunction in AVFs is thrombosis secondary to stenosis. Inflammation appears to be associated with AVF dysfunction and warrants investigation. AVF stenosis results from neointimal hyperplasia and a cascade of inflammatory factors. Various inflammatory parameters have been studied in relation to AVF failure.[3–5] Among these, the neutrophil-to-lymphocyte ratio (NLR) and red cell distribution width (RDW) are strong predictors of inflammation-associated stenosis, thus potentially playing a significant role in AVF stenosis. Due to their effectiveness, low cost, and ease of access, NLR and RDW continue to draw interest as useful markers.[6,7]

The aim of this study is to identify parameters associated with loss of AVF function in patients with ESRD who have undergone AVF creation. In doing so, strategies can be developed to ensure longer AVF patency, thereby reducing associated healthcare costs.

METHODS

Ethics

The study was conducted with the permission of the Erciyes University Clinical Researches Ethics Committee (Date: 04.07.2018, Decision No: 2018/343). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

A prospective study was conducted between 2018 and 2019, involving 146 patients who underwent radiocephalic AVF creation (**Figure**). Only patients with successful radiocephalic AVF formation who did not require any further interventions were included in the study. Preoperative evaluations included the Allen test and detailed physical examination. Surgical success was confirmed by the presence of a palpable thrill. Patients were recalled at the 1st and 5th months postoperatively to assess AVF patency. AVF with HD blood flow rates of 350 ml/min or higher were considered mature. All surgical procedures were performed by two surgeons.

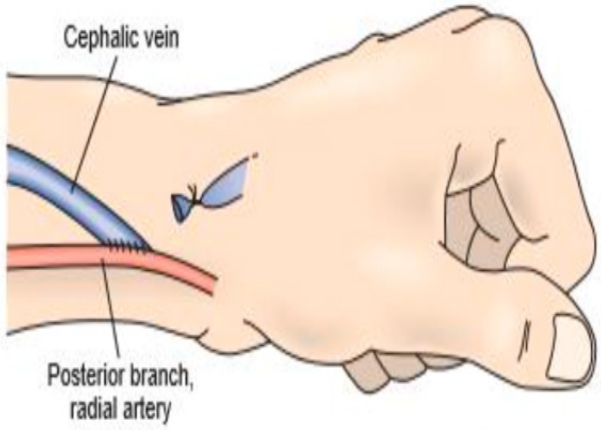

Figure. Autogenous posterior radial branch–cephalic vein (Snuffbox fistula) and autogenous radial-cephalic with direct access (Brescia-Cimino-Appel fistula)
(Reproduced from Silva MB, Hobson RW, Pappas PJ, et al. Vein transposition in the forearm for autogenous hemodialysis access. *J Vasc Surg.* 1997;26:981-988.)

Exclusion criteria were as follows: patients with chronic hepatobiliary and hematological diseases, chronic inflammatory diseases, malignancies, patients taking certain medications (steroids or nonsteroidal anti-inflammatory drugs), and those with acute infections.

Laboratory Analysis

Antecubital venous blood samples were collected from all patients in test tubes upon admission. All standard biochemical tests were performed on an autoanalyzer (Roche Diagnostic Modular Systems, Tokyo, Japan). An automated hematology analysis system (Sysmex K-1000 Hematology Analyzer, Guangdong, China) was used to measure hematological parameters. The NLR was obtained by dividing the neutrophil count by the lymphocyte count.

Statistical Analysis

SPSS 26.0 for Windows (IBM, Armonk, NY, USA) statistical software was used for data analysis. This study employed a case-control methodology. The Shapiro-Wilk test was used to assess the normality of the distribution of the results. Descriptive data were presented as mean or median with standard deviation (interquartile range, IQR), depending on the normality of the distribution. The Mann-Whitney U test was used to compare quantitative variables with non-normal distributions. The Chi-square test was used to compare groups. Group comparisons were performed using t-tests, and continuous variables were reported as mean and standard deviation. Correlations between continuous variables were measured using Pearson's correlation analysis. Multivariate logistic regression analysis was used to assess the association between NLR and AVF maturation. Additionally, 95% CI (confidence intervals) and OR (odds ratio) were calculated. The best cut-off values for NLR were found using receiver operating characteristic (ROC) analysis, which was used to assess the relationship between inflammatory markers and clinical outcome and prognosis prediction. P values less than 0.05 were considered significant.

RESULTS

Patients diagnosed with ESRD who were either scheduled to begin HD or were already undergoing HD treatment were included in our study. A total of 146 patients (83 males, 63 females) were enrolled. Of these, 56.8% were male and 43.2% were female (**Table 1**). The mean age of the patient group was 58.9±11.41 years (**Table 1**).

According to the results, 61.6% of the AVF created matured sufficiently for HD treatment, whereas 38.4% did not reach the level of maturation required for HD.

At the 1-month follow-up, a palpable thrill was detected in 71.2% of patients, while no thrill was detected in 28.8%. At the 3-month follow-up, thrill was present in 67.1% of patients and absent in 32.9% (**Table 1**).

Among male participants, AVF maturation was observed in 73.5%, while this rate was 46% among female participants (**Table 2**). These findings demonstrated a statistically significant relationship between AVF maturation and gender (p=0.001).

Similarly, at the 1st-month follow-up, a thrill was detected in 79.5% of male patients compared to 60.3% of female patients. The 1st-month thrill detection rate in male patients was statistically significantly higher (p=0.011) (**Table 3**).

At the 5th-month follow-up, a thrill was present in 75.9% of male patients and 55.6% of female patients. The thrill rate at 1 month in male patients was found to be statistically significantly higher (p=0.011) (**Table 4**).

Among the 146 patients included in the study, 47.3% had a body-mass index (BMI) below 25, and 52.7% had a BMI of 25 or above. The AVF maturation rate was 71% in patients with a BMI <25, while it was 41% in those with a BMI ≥25. A statistically significant association was found between BMI and AVF maturation (p=0.028) (**Table 2**). AVF maturation was significantly more common in patients with lower BMI.

The 1st-month thrill detection rate was 81.2% in patients with a BMI <25, compared to 62.3% in patients with a BMI ≥25. The 1st-month thrill presence in patients with lower BMI was statistically significantly higher (p=0.012) (**Table 3**).

Similarly, at the 5th-month follow-up, thrill was detected in 76.8% of patients with a BMI <25, and in 58.4% of patients with a BMI ≥25. The 1st-month thrill presence in patients with lower BMI was statistically significantly higher (p=0.012) (**Table 3**).

Among the study participants, 24.0% were on antiplatelet therapy, while 76.0% were not. AVF maturation occurred in 77.1% of patients receiving antiplatelet therapy, compared to 56.8% in those not receiving it. Fistula maturation was

Table 1. Analysis of the entire patient group

		Value
Age (year)		58.9±11.41
Gender (n,%)	Female	63 (43.2%)
	Male	83 (56.8%)
Fistula maturation (n,%)	No	56 (38.4%)
	Yes	90 (61.6%)
1. month thrill (n,%)	No	42 (28.8%)
	Yes	104 (71.2%)
2. month thrill (n,%)	No	48 (32.9%)
	Yes	98 (67.1%)
Body-mass index (kg/m²)	<18.5	15 (10.3%)
	18.5-24.9	54 (37.0)
	25-29.9	52 (35.6%)
	30-39.9	21 (14.4%)
	>40	4 (2.7%)
Smoking (n, %)	No smoking	103 (70.5%)
	<20 package/year	26 (17.8)
	≥20 package/year	17 (11.6)
Hypertension (n, %)	No	49 (33.6%)
	Yes	97 (66.4%)
Diabetes mellitus (n, %)	No	89 (61.0%)
	Yes	57 (39.0%)
Type of anesthesa (n, %)	Local	139 (95.2%)
	Regional	7 (4.8%)
Antiplatelet drugs (n, %)	No	111 (76.0%)
	Yes	35 (24.0%)
Hemoglobin (g/dl)		10.15±1.97
Platelet (10³/μL)		234.50±96.25
White blood cell (10³/μL)		7.95±2.05
Blood urea nitrogen (mg/dl)		52.82±34.72
Creatinine (mg/dl)		5.02±3.91
Glomerular filtration rate (ml/min/1.73m²)		29.35±32.51
Sodium (mmol/L)		134.87±11.73
Potassium (mmol/L)		4.53±0.87
Calcium (mg/dl)		8.45±1.15
Phosphorus (mg/dl)		4.45±1.84
Total protein (mg/dl)		6.38±0.92
Albumin (mg/dl)		3.37±0.65
Aspartate transaminase (U/L)		30.64±21.16
Alanine aminotransferase (U/L)		34.41±20.90
Neutrophil-lymphocyte ratio		2.98±1.80
Red blood cell distribution width (%)		14.84±1.94

significantly higher in patients on antiplatelet therapy (p=0.031) (**Table 2**).

At the 1st-month follow-up, thrill was present in 91.4% of patients on antiplatelet therapy, compared to 64.9% of those not on therapy. The effect of antiplatelet treatment on 1st-month AVF patency was statistically significant (p=0.002) (**Table 3**).

At the 5th-month follow-up, thrill was detected in 82.9% of patients on antiplatelet therapy and 62.2% of those not

Table 2. Association of fistula maturation with clinical parameters

		Maturation		p
		No n (%)	Yes n (%)	
Gender (n,%)	Male	22 (26.5%)	61 (73.5%)	0.001
	Female	34 (54.0%)	29 (46.0%)	
Body-mass index (kg/m²)	<25	20 (29.0%)	49 (71.0%)	0.028
	≥25	36 (46.8%)	41 (53.2%)	
Smoking (n,%)	No	38 (36.9%)	65 (63.1%)	0.574
	Yes	18 (41.9%)	25 (58.1%)	
Hypertension (n,%)	Yes	40 (41.2%)	57 (58.8%)	0.314
	No	16 (32.7%)	33 (67.3%)	
Diabetes mellitus (n,%)	Yes	26 (45.6%)	31 (54.4%)	0.149
	No	30 (33.7%)	59 (66.3%)	
Type of anesthesia (n,%)	Local	52 (37.4%)	87 (62.6%)	0.254
	Regional	4 (57.1%)	3 (42.9%)	
Antiplatelet drugs (n,%)	Yes	8 (22.9%)	17 (77.1%)	0.031
	No	48 (43.2%)	63 (56.8%)	

Table 3. Association of first-month thrill with clinical parameters

		First month thrill		p
		No n (%)	Yes n (%)	
Gender (n, %)	Male	17 (20.5%)	66 (79.5%)	0.011
	Female	25 (39.7%)	38 (60.3%)	
Body-mass index (kg/m²)	<25	13 (18.8%)	56 (81.2%)	0.012
	≥25	29 (37.7%)	48 (62.3%)	
Smoking (n, %)	No	26 (25.2%)	77 (74.8%)	0.145
	Yes	16 (37.2%)	27 (62.8%)	
Hypertension (n, %)	Yes	31 (32.0%)	66 (68.0%)	0.231
	No	11 (22.4%)	38 (77.6%)	
Diabetes mellitus (n, %)	Yes	21 (36.8%)	36 (63.2%)	0.085
	No	21 (23.6%)	68 (76.4%)	
Type of anesthesia (n, %)	Local	41 (29.5%)	98 (70.5%)	0.350
	Regional	1 (14.3%)	6 (85.7%)	
Antiplatelet usage (n, %)	Yes	3 (8.6%)	32 (91.4%)	0.002
	No	39 (35.1%)	72 (64.9%)	

Table 4. Association of fifth-month thrill with clinical parameters

		Fifth month thrill		p
		No n (%)	Yes n (%)	
Gender (n, %)	Male	20 (24.1%)	63 (75.9%)	0.010
	Female	28 (44.4%)	35 (55.6%)	
Body-mass index (kg/m²)	<25	16 (23.2%)	53 (76.8%)	0.018
	≥25	32 (41.6%)	45 (58.4%)	
Smoking (n, %)	No	32 (31.1%)	71 (68.9%)	0.471
	Yes	16 (37.2%)	27 (62.8%)	
Hypertension (n, %)	Yes	36 (37.1%)	61 (62.9%)	0.125
	No	12 (24.5%)	37 (75.5%)	
Diabetes mellitus (n, %)	Yes	22 (38.6%)	35 (61.4%)	0.239
	No	26 (29.2%)	63 (70.8%)	
Type of anesthesia (n, %)	Local	46 (33.1%)	93 (66.9%)	0.581
	Regional	2 (28.6%)	5 (71.4%)	
Antiplatelet drugs (n, %)	Yes	6 (17.1%)	29 (82.9%)	0.023
	No	42 (37.8%)	69 (62.2%)	

receiving therapy. The effect of antiplatelet therapy on 5th-month AVF patency was statistically significant (p=0.023) (Table 4).

The mean age of the patient group was 58.9±11.41 years. Non-parametric analysis using the Mann-Whitney U test revealed a statistically significant relationship between age and AVF maturation (p=0.011) (Table 5). No statistically significant associations were found between AVF maturation and the levels of hemoglobin, platelet count, WBC, BUN, creatinine, GFR, sodium, potassium, calcium, phosphorus, total protein, or albumin (Table 5).

Table 5. The relationship between continuous variables and fistula maturation

	Mean±standard deviation	p
Age (year)	58.9±11.41	0.011
Hemoglobin (g/dl)	10.15±1.97	0.127
Platelet (10^3/μL)	234.50±96.25	0.536
White blood cell (10^3/μL)	7.95±2.05	0.245
Neutrophil-lymphocyte ratio	2.98±1.80	0.014
Red blood cell distribution width (%)	14.84±1.94	0.001
Blood urea nitrogen (mg/dl)	52.82±34.72	0.781
Serum creatinine (mg/dl)	5.02±3.91	0.953
Glomerular filtration rate (ml/min/1.73m^2)	29.35±32.51	0.950
Sodium (mmol/L)	134.87±11.73	0.536
Potassium (mmol/L)	4.53±0.87	0.601
Calcium (mg/dl)	8.45±1.15	0.700
Phosporus (mg/dl)	4.45±1.84	0.726
Total protein (mg/dl)	6.38±0.92	0.459
Albumin (mg/dl)	3.37±0.65	0.810
Aspartate transaminase (U/L)	30.64±21.16	0.344
Alanine aminotransferase (U/L)	34.41±20.90	0.538

The mean NLR was 2.98±1.80. Evaluation of the relationship between NLR and AVF maturation using the Mann-Whitney U test revealed a statistically significant association (p=0.014) (Table 5). The RDW was 14.84±1.94, and its association with AVF maturation was found to be statistically significant (p=0.001) (Table 5).

Among the 146 patients included in the study, 63 (43.2%) were female and 83 (56.8%) were male. AVF maturation was observed in 73.5% of male participants and 46% of female participants (Table 2). These findings demonstrated a statistically significant relationship between AVF maturation and gender (p=0.001).

DISCUSSION

One of the important implications of this study is that NLR and RDW levels, which are considered inflammatory markers, can also be used to predict AVF maturation.

In patients with ESRD undergoing HD, establishing a vascular access with adequate blood flow for regular HD sessions is essential. AVFs are the most commonly used vascular access method for HD. However, AVF loss due to stenosis and thrombosis leads to frequent hospitalizations and significant healthcare costs.[4] Vascular anatomy and technical factors influence AVF maturation, requiring optimal coordination among multiple healthcare professionals, including surgeons, anesthesiologists, nurses, nephrologists, and dialysis unit staff.[8]

Although brachiocephalic AVFs demonstrate better patency rates than radiocephalic AVFs, higher complication rates make radiocephalic AVFs the preferred option.[9] This study focused on patients with radiocephalic AVFs using the most commonly used technique, an end-to-end anastomosis technique with the cephalic vein and radial artery.[10] Current literature reports a primary AVF failure rate ranging from 23% to 37% within the first year and patency rates ranging from 40% to 60%.[11,12] According to the Dialysis Outcomes Quality Initiative, the primary AVF failure rate is approximately 15% in the first year and 25% in the second year.[12] International Kidney Disease guidelines state a primary AVF success rate of 65%. A study by Irish and colleagues[13] observed obstruction and non-maturation rates ranging from 20% to 54%.

In this study, 61.6% of the AVFs created reached sufficient maturity for HD, while 38.4% did not. At 1-month follow-up, 71.2% of patients had a palpable thrill, while 28.8% did not. At 5-month follow-up, 67.1% of patients had a palpable thrill, while 32.9% did not. Advanced age, female gender, diabetes mellitus (DM), and small vessel diameter are known risk factors for AVF failure. Studies on the effect of age on arteriovenous access outcomes often yield conflicting results. However, given the shorter life expectancy in patients with ESRD, the question arises: Should proximal or prosthetic arteriovenous access be the initial approach in elderly patients? A meta-analysis by Lazarides et al.,[14] which included studies comparing elderly and non-elderly patients and forearm and upper arm accesses, found significantly higher AVF failure rates for radiocephalic AVFs at 1 and 2 years in elderly patients. Conversely, studies by Pisoni et al.[15] and others have shown that younger age favors AVF maturation.

A meta-analysis by Lazarides et al.[14] of 13 cohort studies revealed significantly higher radiocephalic AVF failure rates in elderly patients. However, studies by Lok et al.,[16] Swindlehurst et al.,[17] and Weale et al.[18] found no significant association between age and AVF failure. The likelihood of AVF failure appears to be higher in older individuals, which may be attributable to the increased prevalence of DM, hypertension, and peripheral vascular disease in this population. However, current evidence suggests that the relationship between age and AVF maturation is not definitive. In our study, we observed a statistically significantly higher AVF maturation rate in younger patients. This difference may be due to the increased incidence of comorbidities and atherosclerosis in older individuals.

Advanced age, female gender, DM, and small vein caliber are known risk factors for AVF maturation. Studies on the impact of age on arteriovenous access outcomes often yield conflicting results. In a study conducted by Pisoni et al.,[15] male gender was found to positively influence AVF maturation. In contrast, studies by Astor et al.[19] and Rooijens et al.[2] reported no significant difference between sexes. In our study, AVF maturation rates were significantly higher in male patients than in females. This may be explained by the generally larger and more superficial veins observed in males.

Most published reports consist of retrospective observational studies and suggest that DM adversely affects arteriovenous access patency. These reports demonstrate an increased incidence of arterial calcification and atherosclerosis in DM patients. To further evaluate the vascular effects of DM, Sedlacek et al.[20] compared preoperative non-invasive vascular mapping between DM and non-DM patients. While they found increased arterial calcification in DM patients, no significant differences were observed in arterial diameter or in the feasibility of placing autogenous arteriovenous access; however, long-term outcomes were not assessed in that study.[20]

When examining the long-term outcomes in DM patients, Konner et al.[21] reported an increased risk of thrombosis and arterial steal syndrome. Similarly, Kordzadeh et al.[22] found that DM negatively impacted AVF maturation. Pisoni et al.[15] also concluded that the absence of DM was a positive predictor of AVF maturation. Aronson et al.[23] demonstrated that DM-associated metabolic disturbances contribute to prothrombotic events, endothelial injury, dysregulation of growth factors, and extracellular matrix accumulation. These factors may trigger inflammation, which in turn promotes AVF stenosis and thrombosis.[24] In a study involving 31 AVF patients, DM was identified as a negative predictor of venous remodeling; however, the limited sample size may reduce the statistical power of that finding.[25]

Hemodynamic changes stimulate vascular remodeling, and the endothelium actively responds to these stimuli.[26] Previous studies have demonstrated that DM accelerates AVF failure through atherosclerotic mechanisms.[27] In our study, although AVF maturation appeared to be lower in DM patients than in non-DM ones, the difference was not statistically significant.

According to Kim et al.,[28] hypertension is not considered a major risk factor for AVF maturation. Their cohort study, which included 50 patients, also found no significant association between AVF maturation and DM or gender. However, the study may have been underpowered due to the small sample size. Cardiovascular comorbidities, including hypertension, appear to exert less influence on hemodynamic profiles and vascular morphology.[27] Nevertheless, in hypertension, endothelial function is impaired due to reduced vasodilation and increased inflammatory cell infiltration.[29]

Macrophages and T lymphocytes represent key pathological components in the development of atherosclerosis. Neovascularization is initiated at the sites of high shear stress in elastic arteries.[30] In our study, no statistically significant relationship was found between hypertension and AVF maturation.

Serum albumin has emerged in recent years as a prognostic factor for surgical outcomes and AVF patency.[31] However, its precise role in vascular surgery remains unclear. Serum albumin contributes to oncotic pressure and influences various pathophysiological mechanisms including dehydration, malnutrition, wound healing, and edema, all of which impact inflammation and AVF function.[32] Churchill et al.[33] found hypoalbuminemia to be significantly associated with AVF thrombosis, likely due to its role as an indicator of systemic inflammation. Chang et al.[34] observed that infiltration of macrophages and lymphocytes into the vessel wall exacerbates the inflammatory process, contributing to AVF stenosis. Several studies have also implicated thrombosis resulting from inflammation-induced neointimal hyperplasia as a major cause of AVF failure.[35]

Recent studies have identified several preoperative hematological and biochemical markers as prognostic indicators for surgical outcomes. While brachiocephalic AVFs demonstrate better patency rates than radiocephalic ones, their higher complication rates make radiocephalic AVFs the preferred choice. This study focused on patients with radiocephalic AVFs, utilizing the end-to-side anastomosis technique with the cephalic vein and radial artery, which is the most commonly employed method. Among inflammatory markers, RDW has been found to be significantly elevated in patients with AVF failure and is also associated with coronary artery disease and myocardial infarction.[36] The NLR, an indicator of neointimal hyperplasia, negatively affects AVF maturation.[7]

Endothelial dysfunction, commonly observed in renal impairment, results from the presence of uremic toxins in plasma, which disrupt critical endothelial processes such as proliferation, migration, and wound healing.[37] These abnormalities play a central role in vascular remodeling. In AVF creation, endothelial cells undergo rapid proliferation to restore barrier function, permeability, and biochemical regulation, which facilitates vascular repair, localized thrombosis, inflammation, and neointimal hyperplasia.[38] When uremia inhibits endothelial proliferation and migration, abnormal remodeling and neointimal hyperplasia may occur at the anastomosis site, resulting in AVF failure.[3]

Endothelial dysfunction contributes to atherosclerosis by impairing vasoregulation, promoting thrombogenesis, facilitating leukocyte infiltration and lipid accumulation in the intimal layer, and enhancing vascular smooth muscle cell proliferation and migration.[39–42] Atherosclerosis disrupts endothelial integrity, triggers platelet aggregation, and initiates the coagulation cascade, increasing the risk of vascular occlusion.[43] Studies suggest that RDW may be a superior inflammatory marker compared to CRP and WBC in this context.[35]

Establishing effective vascular access is fundamental to successful HD. Selecting the appropriate type and location is crucial to maximizing fistula success and minimizing the need for revisions. Unfortunately, there is no universal criterion for AVF creation. Despite the absence of consensus, autogenous AVFs are generally preferred over grafts, as grafts require 3.8 times more thrombectomy procedures and three times more interventions to maintain patency. Furthermore, AVFs typically require 1.5 to 3.3 additional interventions during their lifespan to maintain access functionality which leads to prolonged hospitalizations and increased healthcare costs.[44]

Therefore, there is a strong need for AVFs that are durable, rapidly maturing, and require fewer interventions. If an AVF functions well during the first six months, it can remain patent for up to 20 years.[45]

CONCLUSION

In our study, age and gender were found to be significantly associated with AVF maturation. Additionally, antiplatelet therapy was positively associated with AVF maturation, while elevated NLR and RDW levels were negatively correlated with successful AVF maturation.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the permission of the Erciyes University Clinical Researches Ethics Committee (Date: 04.07.2018, Decision No: 2018/343).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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