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Comparison of Intima-Media-Thichness, Brachialic Artery VF and VF Draining Vein CKD with Diabetes and Non-Diabetes Performed AVF-Brachiosephiccia at RSCM

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Abstract:
Brachiocephalic arteriovenous fistula (AVF) is the recommended vascular access for long-term hemodialysis. However, AVF failure rates remain high, particularly among patients with diabetes mellitus (DM). Diabetes contributes to vascular structural changes, such as increased intima-media thickness (IMT) and reduced volume flow (VF), which may affect AVF maturation success. To compare changes in IMT, brachial artery volume flow, and draining vein volume flow in chronic kidney disease (CKD) patients with and without DM who underwent brachiocephalic AVF creation. This was a retrospective cohort study conducted at Cipto Mangunkusumo National General Hospital between April and June 2025. A total of 42 CKD patients were enrolled and divided into two groups: 21 with DM and 21 without DM. IMT and volume flow were measured using Doppler ultrasound at weeks 0, 2, and 6 after AVF creation. Data were analyzed using the Mann-Whitney test and independent T-test, depending on data distribution. Forty two participants met the inclusion criteria. No significant differences were found between the DM and non-DM groups regarding changes in brachial artery IMT ($p = 0.918$), brachial artery volume flow ($p = 0.538$), or draining vein volume flow ($p = 0.642$) at week 6. Although both groups showed a trend of increased VF from week 0 to week 6, the differences were not statistically significant. There were no significant differences in changes in IMT, brachial artery volume flow, or draining vein volume flow between CKD patients with and without DM following brachiocephalic AVF creation.

Keywords: Brachiocephalic AVF, intima-media thickness, volume flow, diabetes mellitus, chronic kidney disease.

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INTRODUCTION

Chronic kidney disease (CKD) is a pathological condition characterized by kidney damage and a decrease in glomerular filtration rate (LFG) below 60 ml/min per 1.73 m² that lasts for at least three months. The prevalence of CKD in the general population is estimated to range from 10% to 14%. Based on Global Burden of Disease data, the prevalence of CKD worldwide has increased by 33% during the period from 1990 to 2017 with the highest prevalence rate in developing countries including Indonesia (Bikbov et al., 2020). In Indonesia, the prevalence of CKD increased from 2% in 2013 to 3.8% in 2018, reflecting the increasing trend of the burden of this disease at the national level (Basic Health Research [Riskesdas], 2018).

Management of chronic kidney disease (CKD) in the advanced stages, especially stages 4 and 5, requires preparation for renal replacement therapy (Chen et al., 2019). When kidney function decreases significantly, metabolic waste products are removed through hemodialysis. To achieve optimal hemodialysis efficiency, vascular access with blood flow of about 600 ml/min is required. Some common types of vascular access in clinical practice include arteriovenous fistula (AVF), arteriovenous graft (AVG), and central venous catheter connected to a *dialyzer* (Lee et al., 2020).

An AV fistula is created through a surgical procedure that connects an artery with a vein. This mechanism allows blood flow directly from the arteries to the veins, increasing the pressure as well as the volume of blood flow in the veins. This increase causes the veins to dilate, so that they are able to accommodate the volume of blood flow needed to undergo hemodialysis adequately. AV fistulas are the primary choice of vascular access for long-term dialysis because they have better resistance than other types of access, with a lower risk of infection and stenosis and shorter recovery times, thus providing greater clinical benefits to patients (Bylsma et al., 2017). The most common types of AV fistulas are radiocephalic fistulas, brachiocephalus, and brachiobasilic fistulas. Among the three types, brachiocephalic AV fistula is the most commonly used in clinical practice (Elamurugan & Hemachandar, 2017).

Although brachiocephalic arteriovenous fistula (AV fistula) is a recommended vascular access for long-term hemodialysis, this procedure has a relatively high failure rate. A study conducted by Schinstock et al. (2011) reported that the failure rate of AV fistula in patients with chronic kidney disease (CKD) reached 50%. In addition, of the 50% of AV fistulas that were initially successful, about 25% failed within two years of FAV manufacture. Other vascular access alternatives also showed less than optimal outcomes, with patency rates of 67% for central venous catheters and 58% for arteriovenous grafts (AV grafts). In Indonesia, a study conducted by Ismail et al. (2021) at Dr. Sardjito Hospital Yogyakarta reported a prevalence of AV fistula failure of 27%. The study also identified several risk factors that are significantly associated with AV fistula failure, namely smoking (OR = 5.37; 95% CI, 1.760–16.431; p = 0.002) and diabetes mellitus (OR = 5.00; 95% CI, 1.631–15.503; p = 0.004).

More specifically, research conducted by Bahrami-Ahmadi et al. (2022) indicates that diabetes mellitus may be a risk factor for AV fistula failure, although the association is not statistically significant. Diabetes can cause structural and functional changes in blood vessels, potentially increasing the risk of AVF failure. Studies show that patients with diabetes have a higher rate of AVF failure compared to non-diabetic patients, as well as experience more frequent complications. Therefore, a better understanding of the influence of diabetes mellitus on the creation and function of AVFs is essential to improve clinical outcomes in CKD patients. A meta-analysis conducted by Yan et al. (2018) showed that the rate of AV fistula failure was significantly higher in patients with diabetes compared to non-diabetic patients (OR = 1.682; 95% CI, 1.429–1.981; $p < 0.001$).

Until now, research that specifically evaluates predictive factors of arteriovenous fistula failure (AVF) based on physical examination is limited. However, some studies have compared the parameters of the physical findings with the condition and continuity of AV fistula function indirectly (Siddiqui et al., 2017). One of the comparative studies on AVF patency conducted by Young et al. (2006) identified that the *intima-media thickness of* the radial artery plays a role in the initial failure of radiocephalic AVF. An increase in intima-media thickness contributes to a decrease in the elasticity of blood vessels and a narrowing of the vascular lumen, which ultimately leads to increased arterial stiffness. This mechanism can inhibit optimal blood flow, thereby increasing the risk of AV fistula failure in the early stages after FAV manufacture.

Research conducted by Hentschel (2018) revealed that one of the main determinants in the maturation process of arteriovenous fistula (AVF) is volume *flow*. These findings are reinforced by a study conducted by Allon et al. (2016), which showed a significant correlation between increased flow volume and a higher AVF success rate. Thus, volume flow measurement can serve as a predictive indicator of the success of AV fistula maturation.

Although various studies have examined the factors that contribute to arteriovenous fistula (AVF) failure, studies that specifically evaluate risk factors in the brachial artery of brachiocephalic AV fistula are still limited and have not provided strong conclusions. Therefore, the purpose of this study is to comprehensively analyze the differences in intima-media thickness (BMI) and volume flow (VF) of the brachial artery and VF draining vein in patients with chronic kidney disease with and without diabetes mellitus who undergo the manufacture of brachiocephalic arteriovenous fistulas. The findings of this study are expected to make an important contribution to improving understanding of predictive factors for AV fistula success and supporting the optimization of clinical strategies in vascular access management in patients with chronic renal failure.

RESEARCH METHODS

Research Description

This study uses a retrospective cohort design conducted at Dr. Cipto Mangunkusumo National Hospital Jakarta during April–June 2025. The focus of the study was to compare the intima-media thickness and flow volume in patients with chronic kidney disease (CKD) who have brachiocephalic AV fistulas between the diabetic and non-diabetic groups.

Sampling was performed using a consecutive sampling technique with a total sample of at least 42 participants, based on the calculation from a two-proportion comparison formula. The examination was conducted using a GE Healthcare Logic P9 Doppler ultrasound with a 7–15 MHz linear probe. Data were collected at 2 weeks and 6 weeks after fistula creation, then analyzed using SPSS version 20.0 with Pearson or Spearman correlation tests depending on the data distribution.

Table 1. Research Sample Criteria

Category	Criterion
Inclusion	- Adult CKD patients with brachiocephalic AV fistula - Routine hemodialysis 2-3x/week, 3-4 hours/session, >1 week - Sign informed consent
Exclusion	- Incomplete medical record data - Dysfunction of the first week of AV fistula - Complications: infection, stenosis, sepsis, coagulopathy

Source: Primary data, 2025

Table 2. Operational Variables and Definitions

Variable	Definition	Collection Method	Scale
Independent	Status of diabetes mellitus	Medical record data	Nominal (Any/None)
Dependent	Thickness of the intima of the brachial artery media	Doppler ultrasound	Numerical (mm)
	Brachial artery flow volume	Doppler ultrasound	Numerical (L/minute)
	Volume flow draining vein	Doppler ultrasound	Numerical (L/minute)
Squirt	Age	Anamnesis	Numerical (year)
	Gender	Anamnesis	Nominal (L/P)
	HbA1c	Medical record data	Numerical (mmol/mol)
	Blood sugar during	Medical record data	Numerical (mg/dL)

Source: Primary data, 2025

Table 3. Doppler Ultrasound Examination Protocol

Parameters	Specifications
Tool	Ultrasound Doppler GE Healthcare Logic P9
Probe	Linear probe, 7-15 MHz
Position	Arms 45° from body, elbows resting
Slope	<60°
Inspection Time	2 weeks and 6 weeks post-operative

Source: Primary data, 2025

Table 4. Stages of Data Analysis

Phase	Method	Purpose
Univariate	Kolmogorov-Smirnov normality test	Assess data distribution
	Descriptive (mean/median, percentage)	Sample characteristics
Bivariate	Pearson correlation test (normal data)	Relationships between variables
	Spearman correlation test (abnormal data)	Relationships between variables

Source: Primary data, 2025

The research has received ethical approval from the Ethics Commission of the FK UI-RSCM by applying the principles of autonomy, beneficence, confidentiality, non-maleficence, equality, and fairness.

RESULTS AND DISCUSSION

Subject Characteristics

Table 5. Characteristics of research subjects

Variable	DM (n = 21)	Non-DM (n = 21)	Significance (p-value)
Age (years), (mean ± elementary school)	55.38 ± 9.20	48.10 ± 11.55	0.029a*
Gender, n (%)			0.751b
Man	12 (57,2%)	14 (66,7%)	
Woman	9 (42,8%)	7 (33,3%)	
Systolic Blood Pressure (mmHg), (mean ± SD)	151.67 ± 16.48	149.62 ± 19.43	0.715a
Diastolic Blood Pressure (mmHg), (median; min-max)	78 (65 – 95)	80 (56 – 120)	0.086c

[a] Intergroup difference test with unpaired T test
[b] Test of difference between groups with Chi-square test
[c] Differentiation test between groups with Mann-Whitney test
* Significant value ($p<0.05$)

Source: Primary data, 2025

The characteristics of the research subjects can be seen in Table 6. A total of 42 patients with chronic kidney disease (CKD) undergoing brachiocephalic arteriovenous fistula were included, consisting of 21 patients with diabetes mellitus (DM) and 21 patients without

DM (Non-DM). The mean age in the DM group was 55.38 ± 9.20 years, significantly higher than the Non-DM group which had an average age of 48.10 ± 11.55 years (p = 0.029). Most subjects were male in both groups, with a proportion of 57.2% in the DM group and 66.7% in the Non-DM group, but there was no statistically significant difference (p = 0.751). Systolic and diastolic blood pressure between the two groups also showed no significant difference, with values p = 0.715 and p = 0.086 respectively.

Table 6. Data Normality Test Results

Variable	Statistics	Significance (p-value)[a]
Age	0,979	0,635
Systolic TD (mmHg)	0,988	0,930
Diastolic TD (mmHg)	0,913	0,004*
0-week arterial BMI (mm)	0,885	0,001*
0 week arterial VF (ml/min)	0,793	0,000*
VF draining vein 0 weeks(ml/min)	0,856	0,000*
2-week arterial BMI (mm)	0,880	0,000*
2-week arterial VF (ml/min)	0,837	0,000*
VF draining vein 2 weeks (ml/min)	0,948	0,050*
6-week arterial BMI (mm)	0,914	0,004*
6-week arterial VF (ml/min)	0,788	0,000*
VF draining vein 6 weeks (ml/min)	0,753	0,000*

[a] Test of data normality with Shapiro-Wilk test

* Significant value (p-value <0.05) indicates abnormal data distribution

Source: Primary data processing, 2025

Normality tests were performed on the main variables using the Shapiro-Wilk test, as presented in **Table 7**. The results showed that several variables such as age and systolic blood pressure were normally distributed (**p > 0.05**), whereas most of the other variables such as arterial BMI, arterial VF, and VF draining vein at various measurement times were not normally distributed (**p < 0.05**).

Characteristics of BMI Measurement of brachial artery, VF brachial artery and VF draining vein

Table 7. Results of brachial artery BMI, brachial artery VF and VF draining vein in weeks 0, 2, and 6

Variable	DM (n = 21), median (min-max)	Non-DM (n = 21), median (min-max)	p-value[a]

Arterial BMI (mm)			
0 weeks	0,40 (0,30 – 0,80)	0,40 (0,20 – 0,80)	0,315
2 weeks	0,50 (0,30 – 1,00)	0,50 (0,30 – 0,90)	0,678
6 weeks	0,50 (0,20 – 0,70)	0,40 (0,30 – 0,70)	0,274
VF arteries			
(ml/min)	374,86 (5,51 – 1503,00)	204,86 (37,74 – 2142,00)	0,847
0 weeks	469,26 (98,28 – 1789,00)	743,89 (82,34 – 2531,00)	0,232
2 weeks	844,54 (67,71 – 2833,00)	772,23 (211,21 – 3166,00)	0,070
6 weeks			
VF draining vein (ml/min)			
0 weeks	213,12 (76,16 – 1016,00)	183,75 (14,30 – 629,89)	0,191
2 weeks	601,94 (166,50 – 1008,00)	398,73 (124,56 – 1042,00)	0,642
6 weeks	956,00 (602,34 – 2726,00)	723,00 (603,60 – 1399,00)	0,099

[a] Difference test between groups with the Mann-Whitney test

Source: Primary data processing, 2025

Doppler ultrasound measurement data for weeks 0, 2, and 6 are shown on **Table 8**. The results of the analysis showed that there was no significant difference between the DM and Non-DM groups in the value of arterial BMI, arterial volume flow (VF), or VF draining vein in the three measurement times (**p > 0.05**). However, descriptively there was an increase in arterial VF values from week 0 to week 6 in both groups, but the difference did not reach statistical significance.

Difference in Changes in Results of BMI Measurement of Brachial Arteries, VF of Brachial Arteries and VF Draining Vein in Week 2

Table 8. Normality Test Results Data Difference in BMI Measurement of Brachial Arteries, VF Brachial Arteries and VF Draining Vein in Weeks 0 and 2

Variable	Statistics	Sig. (p-value)[a]
Artery BMI difference 2 weeks (mm)	0,933	0,017*
2-week arterial VF difference (ml/min)	0,946	0,048*
Difference VF draining vein 2 weeks (ml/min)	0,971	0,347

[a] Test of data normality with Shapiro-Wilk test

***** Significant value (p-value <0.05) indicates abnormal data distribution

Source: Primary data processing, 2025

Table 9. Comparison of average measurements in weeks 0 and 2

Variable	DM (n = 21)	Non-DM (n = 21)	p-value
arterial BMI (mm), **median (min-max)**	0,00 (-0,20 – 0,40)	0,00 (-0,30 – 0,30)	0.383a
Arterial VF (ml/min) **median (min-max)**	184,23 (-1210,65 – 1414,14)	440,40 (-2059,66 – 2372,24)	0.061a

VF draining vein (ml/min) **average ± SD**	271.33 ± 336.77	193.23 ± 193.18	0.362b

[a] Differential test between groups for abnormal distribution data with the Mann-Whitney test
[b] Intergroup differential test for normal distribution data with independent T-test

Source: Primary data processing, 2025

To evaluate changes in vascular function after AVF, an analysis was carried out on the difference in measurement results between week 0 and week 2. The normality test of the difference in values is presented in **Table 9**. Results showed that the difference in arterial BMI and arterial VF in week 2 was not normally distributed (**p < 0.05**), while the difference in VF draining vein showed a normal distribution (**p = 0.347**). Furthermore, the comparison of the average difference in scores between the DM and Non-DM groups can be seen in **Table 10**. No significant differences were found in changes in arterial BMI (**p = 0.383**), arterial VF (**p = 0.061**), or VF draining vein (**p = 0.362**) between the two groups two weeks after AVF.

Difference in Difference in BMI Measurement Results of Brachial Arteries, VF Brachial Arteries and VF Draining Vein in Week 6

Table 10. Normality Test Results of Differences in BMI Measurement of Brachial Arteries, VF of Brachial Arteries and VF Draining Vein in Weeks 0 and 6

Variable	Statistics	Sig. (p-value)[a]
6-week arterial BMI difference (mm)	0,954	0,091*
6-week arterial VF difference (ml/min)	0,929	0,012*
Difference VF draining vein 6 weeks (ml/min)	0,797	0,0001*

[a] Test of data normality with Shapiro-Wilk test
* Significant value (p-value <0.05) indicates abnormal data distribution

Source: Primary data processing, 2025

Table 11. Comparison of average BMI measurements of brachial arteries, VF of brachial arteries and VF draining veins at weeks 0 and 6

Variable	DM (n = 21)	Non-DM (n = 21)	p-value
Arterial BMI (mm) **median (min-max)**	0,00 (-0,30 – 0,30)	0,00 (-0,40 – 0,30)	0.918a
Arterial VF (ml/min) **median (min-max)**	479,00 (-1435,29 – 2383,37)	583,50 (-1047,00 – 2663,00)	0.538a
VF draining vein (ml/min) **median (min-max)**	558,66 (127,00 – 2550,40)	568,28 (238,00 – 1239,47)	0.642a

[a] Differential test between groups for abnormal distribution data with the Mann-Whitney test

Source: Primary data processing, 2025

The results of the normality test on the difference in change between week 0 and week 6 are shown in **Table 11**. All variables (arterial BMI, arterial VF, and VF draining vein) showed abnormal distribution (**$p < 0.05$**), so a non-parametric test was used in further analysis. A comparison of the average changes between groups can be seen in **Table 12**. Results showed no significant difference between the DM and Non-DM groups in changes in arterial BMI (**$p = 0.918$**), arterial VF (**$p = 0.538$**), and VF draining vein (**$p = 0.642$**) six weeks after brachiocephalic arteriovenous fistula

RESULTS AND DISCUSSION

Overview of research results

The results showed that there was no statistically significant difference between the DM and non-DM groups on changes in arterial BMI, arterial VF, and VF draining veins, either in week 2 or week 6 post-AVF. Based on the results of the analysis of the characteristics of the subjects (Table 1), the average age of patients in the DM group was higher than in the Non-DM group, and this difference was statistically significant ($p = 0.029$). This is in line with the clinical fact that DM is one of the leading causes of CKD and often occurs in older ages (Provenzano et al., 2019; Charles & Ferris, 2020). Meanwhile, male sex was consistently found to be more common than female in both DM and non-DM patient groups. Systolic blood pressure was also found to be higher in the DM patient group than in non-DM. However, there were no significant differences in sex and blood pressure between the two groups, so these factors are not expected to have a major influence on the difference in Doppler ultrasound measurements in this study.

Comparison of arterial BMI in DM and non-DM patients

Arterial BMI is an important indicator in assessing structural changes in the walls of blood vessels due to atherosclerotic processes or vascular remodeling (Intima-media thickness [BMI], n.d.). This study shows that arterial BMI values tend to increase in both DM and non-DM group patients. The arterial BMI value in DM group patients experienced a significant increase compared to non-DM patients at week 6. However, there was no significant difference between the DM and Non-DM groups at week 2.

This result can be explained according to the theory that patients with diabetes mellitus (DM) have a higher risk of experiencing thickening of the arterial walls due to various interrelated pathophysiological mechanisms. Chronic hyperglycemia in DM patients can trigger the formation of advanced glycation end-products (AGEs), which play a role in inducing oxidative stress and activation of inflammatory pathways in the vascular walls. This process leads to endothelial dysfunction characterized by decreased production of nitric oxide (NO), increased adhesion of inflammatory cells, as well as increased proliferation and migration of vascular smooth muscle cells to intima, which ultimately contributes to the thickening of the arterial intima-media (Mureșan et al., 2024; Vo et al., 2024). In addition, chronic systemic inflammation that often occurs in DM patients also exacerbates vascular

damage through macrophage activation, release of proinflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), as well as faster and more unstable formation of atherosclerotic plaques (Islam et al., 2023).

However, the absence of a significant difference in the 6th week of *follow-up* could be due to a variety of factors, such as a relatively short follow-up period as well as individual variations that affect the vascular adaptation response after arteriovenous fistula.

Comparison of *arterial flow volume* in DM and Non-DM patients

Arterial volume flow (VF) is an important parameter that reflects blood flow through the arteries and has been recognized as one of the main predictors of successful maturation of arteriovenous fistula (AVF). An increase in arterial VF indicates a physiological adaptive response to a decrease in vascular resistance in veins directly connected to arteries after AVF, which is the initial stage of the vascular remodeling process (Oliver, 2018; Pratama et al., 2024). In this study, the average volume of arterial flow increased from week 0 to week 6 in both groups, both patients with diabetes mellitus (DM) and non-diabetes.

Although the average increase in arterial VF in this study was higher in the non-DM group than in the DM group, the difference did not reach statistical significance. This is in line with a study by Santosa et al. (2021) in Padang on 46 patients with chronic kidney disease who underwent AV fistula surgery — consisting of 23 DM patients and 23 non-DM patients — also reported that although there was a significant difference in fistula diameter, no significant differences in blood flow, vein depth, and AV fistula maturation rate were found between the two groups. The conclusions of the study confirm that the status of diabetes mellitus does not significantly affect the success of AV fistula maturation in CKD patients. This is likely due to individual variability in hemodynamic responses and other factors such as comorbidity status, glycemic control, and vascular tissue quality. In addition, according to Mohamed et al. (2023), DM patients are more likely to experience vascular remodeling disorders due to endothelial dysfunction and early arteriosclerosis, which can affect the overall dynamics of arterial blood flow. Therefore, although physiologically it is expected that there is a difference in arterial VF increase between groups, the findings are not significant in this study suggesting that DM is not the only determining factor for the early success of post-AVF hemodynamic changes.

Comparison of *flow* draining vein volume in DM and non-DM patients

Similarly, the volume of flow draining vein increased in both groups during the observation period. VF draining vein is another important indicator in assessing the potential maturation of AV fistulas. Although the average VF draining vein in the DM group tended to be higher at week 6 than in week 0, and increased in the non-DM group, there was no significant difference between groups. This suggests that the process of adaptation of vein draining to the high flow induced by fistula is relatively similar in both groups, or that diabetic factors have not had a significant impact in a short follow-up period. [54]

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maturation of AV fistulas. Although the average VF draining vein in the DM group tended to be higher at week 6 than in week 0, and increased in the non-DM group, there was no significant difference between groups. This suggests that the process of adapting vein draining to the high flow induced by fistula is relatively similar in both groups, or that diabetic factors have not had a significant impact in a short follow-up period (Saputra et al., 2022).

Some limitations in this study need to be considered. First, this study did not consider additional variables that can affect the structure and function of blood vessels such as HbA1c levels, lipid status, and inflammatory markers. Second, a short follow-up period (only up to 6 weeks) may not be enough to capture long-term vascular changes.

CONCLUSION

The conclusions of this study showed that the increase in brachial artery BMI in the first 6 weeks was higher in chronic kidney disease patients with comorbidities of diabetes mellitus, although the difference with the non-diabetic group was not statistically significant. Both groups experienced increased volume of post-AVF brachial artery flow, but the difference was not significant at week 2 or week 6. The volume of drainage venous flow was also increased in both groups, but without a significant difference between diabetic and non-diabetic. These findings indicate that although the initial hemodynamic parameters are relatively similar, diabetes mellitus can affect morphological aspects of blood vessels that have the potential to impact long-term maturation success. Therefore, follow-up studies with longer observation periods are needed to assess the long-term effects of diabetes on vascular changes and maturation of arteriovenous fistulas, with additional parameters such as vascular resistance, glycemic control, inflammatory status, and nutritional status.

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