Eduvest – Journal of Universal Studies
Volume 6 Number 5, May, 2026
p- ISSN 2775-3735- e-ISSN 2775-3727

# The Effect of Cephalic Arch Stenosis Location on Angioplasty Success and Patency at 3 and 6 Months in Patients with Brachiocephalic Fistula

**Peri Handayani*, Patrianef, Wawan Mulyawan**
Universitas Indonesia
Emails: drperihandayani@gmail.com*, patrianef@gmail.com, wmulyawan2000@gmail.com

**Keywords**
stenosis location;
cephalic arch stenosis;
angioplasty;
patency;
brachiocephalic fistula;
hemodialysis.

**ABSTRACT**
Failure of maturation and stenosis are major obstacles to arteriovenous fistula patency in hemodialysis patients. The cephalic arch commonly develops vascular dysfunction and can be divided into four domains. However, no study in Indonesia has evaluated the effect of cephalic arch stenosis location on angioplasty outcomes. This study aimed to determine the relationship between the location of cephalic arch stenosis and angioplasty success, as well as 3- and 6-month patency in patients with brachiocephalic fistulas, and to identify influencing factors. This retrospective cohort study included 68 patients with cephalic arch stenosis and brachiocephalic fistulas treated in outpatient clinics or inpatient wards at Cipto Mangunkusumo Hospital (RSCM) from January 2022 to December 2024. Data were obtained from medical records. Bivariate analysis was performed using the Chi-square or Fisher's exact test, and multivariate analysis was conducted using Firth logistic regression. The angioplasty success rate was 91.2%, with 3-month patency of 87.1% and 6-month patency of 66.7%. Multivariate analysis showed that stent use was significantly associated with reduced 3-month patency after angioplasty (OR 0.12; 95% CI 0.02–0.93; p = 0.042), and a cephalic arch insertion angle ≥60° was associated with decreased 6-month patency after angioplasty (OR 0.23; 95% CI 0.06–0.77; p = 0.017). Stenosis location, age, sex, degree and length of stenosis, cephalic arch insertion angle, number of balloons, balloon size, balloon pressure, balloon type, stent use, hypertension, and diabetes were not associated with residual stenosis or with 3- and 6-month patency after angioplasty.

## INTRODUCTION

Chronic kidney failure has high morbidity and mortality rates (Luyckx et al., 2018). In Indonesia, the prevalence of chronic kidney disease in the population aged ≥15 years was 713,783 (0.38%) cases in 2018 (Badan Penelitian dan Pengembangan Kesehatan, 2018). The condition led to National Health Insurance (JKN) financing of 2.3 trillion rupiah during 2019 (Tantinius et al., 2023). As an essential procedure in Indonesia, routine hemodialysis is undergone by 2,850 (19.3%) patients with chronic kidney failure (Badan Penelitian dan Pengembangan Kesehatan, 2018).

Arteriovenous fistula (AVF), as the best option for hemodialysis access because it provides the lowest complication rate, is associated with the highest patient survival rate, and is recommended by the Kidney Disease Outcomes Quality Initiative (KDOQI) (Woods et al.,

1997; Xue et al., 2003; Dhingra et al., 2001; Lok et al., 2020; Eknoyan et al., 2012). The development of venous stenosis is one of the leading causes of vascular access dysfunction and thrombosis (Schwab et al., 1989; Olsson et al., 2001). Thrombosis usually occurs following a reduction in blood flow due to increased resistance caused by venous stenosis of the fistula (Besarab et al., 1995). In fact, central stenosis of the cephalic arch (the part of the cephalic vein that forms an almost perpendicular angle in the deltopectoral groove before joining the axillary vein) is a known contributor to stenosis in upper arm fistula dysfunction. The incidence and prevalence of cephalic arch stenosis reported in the literature vary widely, ranging from 4.25–64%. Its prevalence also depends on the location of AVF in the upper arm, with brachiocephalic fistula (BCF) more often involved compared to radiocephalic fistula (RCF). Clinically, cephalic arch stenosis is defined as a narrowing of more than 50% of the lumen of the cephalic arch (Abdelsalam, 2022; Kim et al., 2022; Pisano et al., 2024). It has been hypothesized that its development is related to the hemodynamics of BCF, due to the high rate of blood flow and the absence of diffuse flow to the basilic veins (Rajan et al., 2003).

The pathophysiology of cephalic arch stenosis is still not fully understood. Several mechanisms have been proposed, including changes in blood flow, external compression by the fascia and pectoralis major muscles, the anatomy of the cephalic curve and the angle of entry of the cephalic vein into the axillary vein, turbulent flow, and the presence of multiple valves (Kian & Asif, 2008). Bennett et al. (2015) divided cephalic arch stenosis into four domains to establish a standardized classification of the cephalic arch segment so that measurements can be made accurately and consistently. The location of cephalic arch stenosis segments may have significance for the etiology of stenosis and possible differences in response to angioplasty.

Several previous studies have examined factors affecting central stenosis as well as the effectiveness of angioplasty. Jaberi et al. (2007) examined risk factors for cephalic arch stenosis in 18 patients, finding significant differences between groups with and without stenosis in BCF location ($p=0.046$), access flow ($p=0.012$), and absence of diabetes ($p=0.03$). However, the insertion angle of the cephalic vein was not a predictive factor for cephalic arch stenosis in that study. Tantinius et al. (2023) reported that factors affecting 6-month primary patency after single balloon angioplasty in 76 patients with central venous stenosis were male sex ($p=0.004$), stenosis length ≥2 cm ($p=0.042$), location of innominate vein stenosis ($p=0.002$), stenosis degree ≥80% ($p=0.001$), and residual stenosis ≥30% ($p=0.013$). Alwi et al. (2021) reported that central venous patency rates after single balloon angioplasty at 3, 6, and 12 months were 54.1%, 28.4%, and 9.2%, respectively, with lesion length and initial stenosis degree as significant factors.

To date, no study has reported the effect of cephalic arch stenosis location on angioplasty success and 3- and 6-month patency in patients with BCF, particularly in the Indonesian population. Therefore, this study aims to determine the relationship between cephalic arch stenosis location and angioplasty success as well as 3- and 6-month patency in patients with BCF. The novelty of this research lies in its domain-based analysis of cephalic arch stenosis location and its association with angioplasty outcomes, which has not been previously conducted in Indonesia. The research urgency is high because understanding location-specific outcomes can guide interventional strategies and improve vascular access management. The

practical benefit of this study is to provide evidence-based guidance for vascular surgeons in selecting appropriate interventions based on stenosis location.

## METHOD

This study used an analytical retrospective cohort design and utilized secondary data from brachiocephalic access hemodialysis patients who were treated at Cipto Mangunkusumo Hospital from January 2022 to December 2024 and managed with angioplasty. The research was conducted at the Department of Vascular and Endovascular Surgery, FKUI, Cipto Mangunkusumo Hospital, from September to November 2025.

The target population of this study consisted of chronic kidney failure patients who underwent hemodialysis and had hemodialysis access in the form of a mature brachiocephalic fistula, then developed stenosis of the cephalic arch, which was diagnosed through anamnesis and clinical examination at a polyclinic or treatment room in Indonesia. The accessible population in this study was the target population diagnosed in polyclinics or treatment rooms at Cipto Mangunkusumo Hospital during the period from January 2022 to December 2024. The study sample consisted of the accessible population that met the inclusion criteria and did not meet the exclusion criteria.

Subjects in this study were patients with cephalic arch stenosis who came for follow-up at the polyclinic or were treated in the inpatient ward of Cipto Mangunkusumo Hospital during the period January 2022–December 2024, and who met the inclusion and exclusion criteria. Subject data were collected from patient databases in the Division of Vascular and Endovascular Surgery and from medical records. The research sample consisted of patients who underwent angioplasty at Cipto Mangunkusumo Hospital, performed by vascular and endovascular surgery trainees and consultants. Collected data included stenosis location, age, sex, degree of stenosis, length of stenosis, cephalic arch insertion angle, number of balloons, balloon size, balloon pressure, balloon type, use of stents, hypertension, diabetes, as well as angioplasty success, and 3-month and 6-month patency outcomes.

The angioplasty procedure was carried out by vascular and endovascular surgeons, both trainees and consultants, at the vascular access unit of Cipto Mangunkusumo Hospital. Before the procedure began, patients had undergone a diagnostic process that included anamnesis, physical examination, and a supporting examination in the form of Doppler ultrasound. After asepsis and antisepsis of the surgical area were performed, puncture was made at the predetermined vascular access site. The first stage was angiography using contrast media to thoroughly evaluate the anatomy of the vascular access while confirming the location of stenosis. After the stenosis location was identified, measurements were taken of the degree of narrowing and the length of the stenotic lesion. Balloon size selection was adjusted to the diameter and length of the narrowed segment. Next, a catheter was inserted through the stenotic area, followed by balloon angioplasty. The balloon was then inflated using nominal pressure until it reached the rated burst pressure (RBP) to dilate the stenotic area, usually performed one to three times. Afterward, a final angiography was performed to assess the success of the angioplasty procedure.

The data in this study were first analyzed descriptively to assess the distribution of both independent and dependent variables. Categorical data were presented as frequencies (n) and percentages (%). Numerical data were presented as means and standard deviations if normally

distributed, or medians and ranges if not normally distributed. Data normality was tested using the Shapiro–Wilk test.

Inferential analysis was performed using several statistical tests depending on the variables. The bivariate relationship between categorical independent and dependent variables was analyzed using the Chi-square test when assumptions were met, and the Fisher's exact test when assumptions were not met. A p-value of <0.05 was considered statistically significant. Variables with $p < 0.25$ were further analyzed using multivariate logistic regression. The multivariate test was considered significant at $p < 0.05$. If a categorical independent variable, after numerical transformation, had a significant effect on patency in the multivariate analysis, the relationship was further analyzed using ROC curve analysis to determine sensitivity and specificity for 3- and 6-month post-angioplasty patency.

## RESULT AND DISCUSSION

### Bivariate Analysis

Bivariate analysis using Chi-square or Fischer tests was performed to assess the relationship between each of the independent and confounding variables with the success of angioplasty assessed from residual stenosis after angioplasty. Variables with a p< value of 0.25 were proceeded to multivariate analysis. Of the 68 patients who underwent angioplasty, angioplasty was successfully performed on 62 people with a success rate of 91.2%. From table 4.3, there were no independent variables that had an effect on the success of angioplasty based on bivariate tests.

**Table 1 Bivariate analysis between independent variables and the success of angioplasty**

| Variable | Angioplasty Success | Value p |
|---|---|---|
| **Location** | | |
| **A** | 7 (11,3%) | 0,638 |
| **B** | 17 (27,4%) | |
| **C** | 26 (41,9%) | |
| **D** | 12 (19,4%) | |

Chi Square test, significant if p<0.05

Of the 62 patients who successfully underwent angioplasty, angioplasty had a 3-month patency in 54 people with a 3-month patency rate of 87.1%. From table 1, there were no independent variables that affected the patency of 3 months post-angioplasty based on bivariate tests.

**Table 2 Bivariate analysis of independent variables with patency 3 months post-angioplasty**

| Variable | Patency 3 months post-angioplasty | Value p |
|---|---|---|
| Location | | |
| A | 7 (13%) | 0,322 |
| B | 16 (29,6%) | |
| C | 22 (40,7%) | |
| D | 9 (16,7%) | |

Chi Square test, significant if p<0.05

Of the 54 patients who experienced 3-month patency post-angioplasty, angioplasty had 6-month patency in 36 people with a 6-month patency rate of 66.7%. From table 2, there were no independent variables that affected patency at 6 months post-angioplasty based on bivariate tests.

**Table 3 Bivariate analysis between independent variables with patency 6 months post-angioplasty**

| Variable | Patency 6 months post-angioplasty | Value p |
|---|---|---|
| Location | | |
| A | 4 (11.1%) | 0,952 |
| B | 11 (30,6%) | |
| C | 15 (41,7%) | |
| D | 6 (16,7%) | |

Chi Square test, significant if p<0.05

From table 3, only the male sex decreased the success rate of angioplasty (p=0.034; OR 0.846; 95%CI: 0.740-0.967). Meanwhile, other confounding variables had no effect on the success of angioplasty.

**Table 4 Bivariate analysis of confounding variables with the success of angioplasty**

| Variable | Angioplasty Success | Value p |
|---|---|---|
| Age, n (%) | | 0,658# |
| ≥60 years old | 21 (87,5%) | |
| <60 years old | 41 (93,2%) | |
| Gender, n (%) | | 0,034# |
| Male | 33 (84,6%) | |
| Women | 29 (100%) | |
| Degree of stenosis, n (%) | | 0,421# |
| ≥ 80% | 29 (87,9%) | |
| < 80% | 33 (94,3%) | |
| Panjang stenosis, n (%) | | 0,390# |
| ≥ 2 cm | 25 (86,2%) | |
| < 2 cm | 37 (94,9%) | |
| Cephalic arch angle, n (%) | | 1,000# |
| ≥ 60 | 37 (90,2%) | |
| < 60 | 25 (92,6%) | |
| Number of balloons, n (%) | | 0,080# |
| Multiple | 25 (83,3%) | |
| Single | 37 (97,4%) | |
| Balloon size, n (%) | | 1,000# |
| ≥ 10 mm | 30 (90,9%) | |
| < 10 mm | 32 (91,4%) | |
| Balloon pressure, n (%) | | 0,097# |
| ≥ 10 atm | 51 (94,4%) | |
| < 10 atm | 11 (78,6%) | |
| Types of balloons | | 0,450# |
| POBA | 46 (93,9%) | |
| PCB | 11 (84,6%) | |
| DCB | 5 (83,3%) | |
| Stent, n (%) | | 0,379# |
| Yes | 4 (80%) | |
| No | 58 (92,1%) | |
| Hypertension, n (%) | | 0,413# |

| | | |
|---|---|---|
| Yes | 39 (88,6%) | |
| No | 23 (95,8%) | |
| Diabetes, n (%) | | 0,390[#] |
| Yes | 26 (96,3%) | |
| No | 36 (87,8%) | |

*Chi Square test, significant if p<0.05

[#]Fischer test, significant if p<0.05

From table 5, there were no confounding variables that affected patency at 3 months post-angioplasty based on bivariate tests.

**Table 5. Bivariate analysis of confounding variables with patency 3 months post-angioplasty**

| Variable | Patency 3 months post-angioplasty | Value p |
|---|---|---|
| Age, n (%) | | 1,000 [#] |
| ≥60 years old | 18 (85,7%) | |
| <60 years old | 36 (87,8%) | |
| Gender, n (%) | | 0,264[#] |
| Male | 27 (81,8%) | |
| Women | 27 (93,1%) | |
| Degree of stenosis, n (%) | | 0,456[#] |
| ≥ 80% | 24 (82,8%) | |
| < 80% | 30 (90,9%) | |
| Panjang stenosis, n (%) | | 0,250[#] |
| ≥ 2 cm | 20 (80%) | |
| < 2 cm | 34 (91,9%) | |
| Cephalic arch angle, n (%) | | 0,250 [#] |
| ≥ 60 | 34 (91,9%) | |
| < 60 | 20 (80%) | |
| Number of balloons, n (%) | | 0,456[#] |
| Multiple | 23 (92%) | |
| Single | 31 (83,8%) | |
| Balloon size, n (%) | | 0,258 [#] |
| ≥ 10 mm | 28 (93,3%) | |
| < 10 mm | 26 (81,3%) | |
| Balloon pressure, n (%) | | 1,000[#] |
| ≥ 10 atm | 44 (86,3%) | |
| < 10 atm | 10 (90,9%) | |
| Types of balloons | | 0,602[#] |
| POBA | 40 (87%) | |
| PCB | 9 (81,8%) | |
| DCB | 5 (100%) | |
| Stent, n (%) | | 0,077[#] |
| Yes | 2 (50%) | |
| No | 52 (89,7%) | |
| Hypertension, n (%) | | 0,698[#] |
| Yes | 33 (84,6%) | |
| No | 21 (91,3%) | |
| Diabetes, n (%) | | 0,262[#] |
| Yes | 21 (80,8%) | |
| No | 33 (91,7%) | |

*Chi Square test, significant if p<0.05
#Fischer test, significant if p<0.05

From table 6, there were no confounding variables that had an effect on patency at 6 months post-angioplasty based on bivariate tests.

**Table 6 Bivariate analysis of confounding variables with patency 6 months post-angioplasty**

| Variable | Patency 6 months post-angioplasty | Value p |
|---|---|---|
| Age, n (%) | | 0,126# |
| ≥60 years old | 15 (83,3%) | |
| <60 years old | 21 (58,3%) | |
| Gender, n (%) | | 0,773# |
| Male | 17 (63%) | |
| Women | 19 (70,4%) | |
| Degree of stenosis, n (%) | | 0,771# |
| ≥ 80% | 15 (62,5%) | |
| < 80% | 21 (70%) | |
| Panjang stenosis, n (%) | | 0,618# |
| ≥ 2 cm | 12 (60%) | |
| < 2 cm | 24 (70,6%) | |
| Cephalic arch angle, n (%) | | <0.001* |
| ≥ 60 | 16 (47,1%) | |
| < 60 | 20 (100%) | |
| Number of balloons, n (%) | | 0,627# |
| Multiple | 14 (60,9%) | |
| Single | 22 (71%) | |
| Balloon size, n (%) | | 0,211 # |
| ≥ 10 mm | 16 (57,1%) | |
| < 10 mm | 12 (76,9%) | |
| Balloon pressure, n (%) | | 0,273# |
| ≥ 10 atm | 31 (70,5%) | |
| < 10 atm | 5 (50%) | |
| Types of balloons | | 0,245# |
| POBA | 25 (62,5%) | |
| PCB | 6 (66,7%) | |
| DCB | 5 (100%) | |
| Stent, n (%) | | 0,547# |
| Yes | 2 (100%) | |
| No | 34 (65,4%) | |
| Hypertension, n (%) | | 0,139# |
| Yes | 19 (57,6%) | |
| No | 17 (81%) | |
| Diabetes, n (%) | | 0,767# |
| Yes | 15 (71,4%) | |
| No | 21 (63,6%) | |

*Chi Square test, significant if p<0.05
#Fischer test, significant if p<0.05

Furthermore, an analysis was carried out with classification based on the location of the most common cephalic arch stenosis (location C) with other locations. From table 7, location

C had no effect on the success of angioplasty based on bivariate tests.

**Table 7 Bivariate analysis between location variable C and angioplasty success**

| Variable | Angioplasty Success | Value p |
|---|---|---|
| Location | | |
| C | 26 (86,7%) | 0,394 |
| Non-C | 36 (94,7%) | |

Fischer test, significant if p<0.05

From table 8, location C had no effect on patency at 3 months post-angioplasty based on bivariate tests.

**Table 8 Bivariate analysis between location variable C with patency of 3 months of angioplasty**

| Variable | Angioplasty Success | Value p |
|---|---|---|
| Location | | |
| C | 22 (84,6%) | 0,710 |
| Non-C | 32 (88,9%) | |

Fischer test, significant if p<0.05

From table 9, location C had no effect on patency at 6 months post-angioplasty based on bivariate assays.

**Table 9 Bivariate analysis of location variable C with patency 6 months post-angioplasty**

| Variable | Angioplasty Success | Value p |
|---|---|---|
| Location | | |
| C | 15 (68,2%) | 1,000 |
| Non-C | 21 (65,6%) | |

Fischer test, significant if p<0.05

**Multivariate Analysis**

The model used is Firth logistic regression due to slight angioplasty failure (n=6). Variables with a p<0.25 value in the bivariate analysis were included in the model, namely gender, number of balloons, and balloon pressure. Variables with a p<0.05 value are considered statistically significant. The results of the multivariate analysis are presented in Table 4.12. It was found that after adjusting for confounding variables, male sex (OR 0.11; 95% CI 0.0008–1.02; p=0.053) and multiple balloon use (OR 0.20; 95% CI 0.02 – 1.17; p=0.075) had a lower probability of angioplasty success (residual stenosis <30%). The use of high-pressure balloons gave a higher probability of angioplasty success (OR 3.85; 95% CI 0.63-24.43; p=0.14), although not statistically significant.

**Table 10. Multivariate analysis between sex, balloon count, and balloon pressure with successful angioplasty**

| Variable | COEF | OR | 95% CI | Value p |
|---|---|---|---|---|
| Male | -2,23 | 0,11 | 0,0008 – 1,02 | 0,053 |
| Multiple balloon | -1,61 | 0,20 | 0,02 – 1,17 | 0,075 |
| Balloon pressure >=10 atm | 1,35 | 3,85 | 0,63 - 24,43 | 0,14 |

*Firth logistic regression test, significant if p<0.05

The model used was Firth logistic regression due to minimal 3-month post-angioplasty patency failure (n=8). Variables with a p<0.25 value in bivariate analysis were included in the model, i.e. the use of stents. Variables with a p<0.05 value are considered statistically significant. The results of the multivariate analysis are presented in Table 11. It was found that after adjustment for confounding variables, stent use was significantly associated with reduced patency at 3 months post-angioplasty (OR 0.12; 95% CI 0.02–0.93; p = 0.042).

**Table 11 Multivariate analysis of independent variables with patency 3 months post-angioplasty**

| Variable | COEF | OR | 95% CI | Value p |
|---|---|---|---|---|
| Use of stents | -2,09 | 0,12 | 0,02 – 0,93 | 0,042 |

*Firth logistic regression test, significant if p<0.05

The model used was Firth logistic regression due to minimal patent failure at 6 months post-angioplasty (n=18). Variables with a p<0.25 value in the bivariate analysis were included in the model, namely age, cephalic arch insertion angle, balloon size, balloon type, and hypertension. Variables with a p<0.05 value are considered statistically significant. The results of the multivariate analysis are presented in Table 12. It was found that after adjustment for confounding variables, the insertion angle of the cephalic arch ≥ 60 decreased patency 6 months post-angioplasty (OR 0.23; 95% CI 0.06–0.77; p = 0.017). Meanwhile, confounding variables such as age (OR 1.37; 95% CI 0.41–4.66; p = 0.607), balloon size (OR 1.45; 95% CI 0.47–4.84; p = 0.520), balloon type (OR 1.51; 95% CI 0.39–6.09; p = 0.547), and hypertension (OR 0.48; 95% CI 0.14–1.59; p = 0.231) had no effect on patency at 6 months post-angioplasty.

**Table 12 Multivariate analysis of independent variables with patency 3 months post-angioplasty**

| Variable | COEF | OR | 95% CI | Value p |
|---|---|---|---|---|
| Insertion angle ≥ 60 | - 1,46 | 0,23 | 0,06–0,77 | 0,017 |
| Age ≥ 60 years old | 0,31 | 1,37 | 0,41–4,66 | 0,607 |
| Size ≥ 10 mm | 0,37 | 1,45 | 0,47–4,84 | 0,520 |
| Non-POBA | 0,41 | 1,51 | 0,39–6,09 | 0,547 |
| Hypertension | - 0,74 | 0,48 | 0,14–1,59 | 0,231 |

*Firth logistic regression test, significant if p<0.05

**Demographic and clinical characteristics**

In this study, the majority of cephalic arch stenosis was found in men (57.4%), hypertension (64.7%), and non-diabetics (60.3%). This is supported by the research of Pisano et al. (2024) who are also predominantly male (65.6%). Similar findings were found by Tirinescu et al. (n.d.) who found that men are a significant risk factor for arteriovenous access stenosis.

Patients with cephalic arch stenosis are more likely to experience hypertension due to high wall shear stress. This is supported by research by Pisano et al. (2024) who are also predominantly male (65.6%). High flow can lead to complications such as heart failure, coronary ischemia, and left ventricular hypertrophy. The interaction between brachiocephalic anatomy and access flow explains how these hemodynamics affect arch cephalic stenosis, through changes in flow velocity, wall shear stress, and vessel elasticity mismatches. If the

body is unable to remodel (structural adjustment), then maladaptive remodeling can occur. High shear stress is known to affect vessel morphology by triggering endothelial cell activity, such as the release of NO and endothelin-1. The interaction between fistula age and brachiocephalic type supports the role of chronic injury and high flow to the development of arch cephalic stenosis (Jaberi et al., 2007).

Less diabetic conditions are found in patients with cephalic arch stenosis. This figure is consistent with the study by Pisano et al. (2024) which found that only 36.5% of patients with cephalic arch stenosis develop diabetes. Regarding systemic diseases, diabetes actually shows a negative association with cephalic arch stenosis, possibly due to lower access flow due to vascular stiffness (Jaberi et al., 2007). Another hypothesis by Tirinescu et al. (n.d.) also reported similar things, where diabetes and obesity appear to be associated with a lower risk or severity of fistula stenosis arteriovenous. This can occur due to the "reverse epidemiology" of hemodialysis patients, where malnutrition, inflammation, and atherosclerosis are associated as major risk factors for cardiovascular disease. This leads to a higher BMI associated with better cardiovascular output and better arteriovenous patency. Diabetes may also be explained by a similar mechanism.

**Relationship of procedural factors with angioplasty success and patency 3 and 6 months post-angioplasty in patients with cephalic arch stenosis**

Of the 68 patients who underwent angioplasty, angioplasty was successfully performed on 62 people with a success rate of 91.2%. Of the 62 patients who successfully underwent angioplasty, angioplasty had a 3-month patency in 54 people with a 3-month patency rate of 87.1%. Of the 54 patients who experienced 3-month patency post-angioplasty, angioplasty had 6-month patency in 36 people with a 6-month patency rate of 66.7%.

The success of angioplasty and patency 3 and 6 months post-angioplasty in our study were higher than those by Pisano et al. (2024). They found that the use of stent graft as the first intervention (before PTCA) showed higher success than PTCA alone (85% vs 61%, $p = 0.003$). Stent grafts also showed better primary patency compared to PTCA (patency 79%, 73%, 60% at 3, 6, 9 months; compared to 71%, 51%, 47%; $p = 0.195$) as well as better cumulative patency (73%, 61%, 61% at 1, 2, 3 years; compared to 60%, 34%, 26%; $p < 0.001$). Of the variables analyzed, the technical success of PTCA was the only distinguishing factor (coefficient of –1.01; RR 35%; $p = 0.035$) (Pisano et al., 2024).

In this study, the number, size, pressure, and type of balloons had no effect on the success of angioplasty and patency 3 and 6 months after angioplasty in patients with cephalic arch stenosis. The central vein patency rate in Alwi et al.'s (2021) study was much lower than that of several other studies that assessed angioplasty in central venous stenosis. One of the factors that is suspected to cause this difference is the type of angioplasty instrument used. In the study, the procedure was performed using POBA, while endovascular therapy for central venous stenosis generally used standard balloons such as cutting balloons or paclitaxel-eluting balloons (Alwi et al., 2021). Tripsianis et al. (2021) reported that the use of high-pressure balloons resulted in significantly higher patency rates at the 6th and 12th months post-angioplasty compared to non-high pressure POBAs. A meta-analysis by Aftab et al. (2014) also showed that venous patency was better in patients treated with standard balloons than in POBA. Cakir et al. (2022) found a first-month patency of 94.4% in POBA and 100% in PEBA.

In the third month, PEBA patents remained at 100%, while POBA dropped to 66.7%. In the sixth month, POBA patency decreased to less than 20%, while PEBA patency still remained above 85%.

**The relationship between the degree of stenosis and the success of angioplasty in patients with cephalic arch stenosis**

In this study, no association was found between the degree of stenosis and the success of angioplasty in patients with cephalic arch stenosis, from both bivariate and multivariate tests. These results are different from similar studies by Alwi et al. (2021). In the study, the degree of early stenosis was shown to be related to the success of the single balloon angioplasty procedure. A total of 51 patients with 50–80% initial stenosis successfully underwent the procedure. Meanwhile, the success rate in patients with stenosis >80% only reached 44.6%. Patients with stenosis of 50–80% had a 31.62 times higher chance of success (95% CI 7–142.83) than patients with initial stenosis >80% ($p<0.001$) (Alwi et al., 2021). These findings are in line with the report of Muradi et al. (2019), which showed that patients with stenosis <80% had a single balloon angioplasty success rate of about 80%.

The presence of venous stenosis downstream causes an inflow–outflow mismatch that results in increased pressure in the access. In this condition, the Qa value may decrease, increase, or remain within normal limits, depending on the relationship between the patient's baseline Qa, the degree of narrowing of the lumen due to the lesion, and the availability of collateral outflow. The decision to treat cephalic arch stenosis is highly dependent on the presence or absence of symptoms (high venous pressure and/or prolonged bleeding). If it is asymptomatic, the stenosis is not treated; if symptomatic, subsequent decisions depend on the volumetric flow (Qa) of vascular access.

If the Qa > 1.2 L/min, then the flow reduction procedure (banding) is carried out first (target Qa: 600–800 mL/min). If the patient remains symptomatic after the procedure, then cephalic arch stenosis will be treated (Daoui & Asif, 2012; Remuzzi & Ene-Iordache, 2013). However, volume flow data in medical records are not found evenly and therefore cannot be variable, even though previous studies have shown that volume flow affects the incidence of cephalic arch stenosis restenosis (Remuzzi & Ene-Iordache, 2013).

**The relationship between stenosis location and angioplasty success and patency 3 and 6 months post-angioplasty in patients with cephalic arch stenosis**

In this study, arch stenosis was most often found at location C (44.1%) followed by location B (26.5%), location D (19.1%), and location A (10.3%). The results of this study are similar to previous studies. In the study Bennett et al. (2015) stenosis was most commonly found in domain IV (72.5%), followed by domain III (56.5%), domain II (40.6%), and domain I (17.4%). In the study by Sarala et al. (2018), there were not many differences from the domain of cephalic arch stenosis, but domain IV (location C) was more commonly affected than other domains of the cephalic arch.

For reasons that are still under investigation, the cephalic arch has a fairly high tendency to develop stenosis. Various mechanisms for the occurrence of cephalic arch stenosis have been proposed, including venous adaptation due to changes in shear stress that induce intima hyperplasia, as well as hypertrophic remodeling related to increased transmural venous blood

pressure after fistula creation (Kian & Asif, 2008; Turmel-Rodrigues et al., 2000). Venous valves, musculoskeletal compression, and limited venous mobility in the deltopectoral groove are also thought to contribute to pathology in the arcus under certain conditions. Given that venous valves are often found in the distal cephalic arch, this may explain why stenosis is more common in that region (Shemesh et al., 2008). In addition, pressure and flow may be highest in the terminal domain (domain IV or location C) and thus play a role in the formation of stenosis. More research is needed to determine whether certain domains are more prone to thrombosis than stenosis or other complications. In addition, as researchers continue to evaluate the therapeutic outcomes of each arch domain separately, it is expected that it will be known whether certain interventions provide better durability or decrease morbidity.

Domain segmentation is important because it can provide clues about the etiology of stenosis (e.g., valve consequence), and each domain may also exhibit a different response to angioplasty and/or stenting placement. Various reviews have associated cephalic arch with higher levels of angioplasty resistance, greater balloon inflation pressure requirements, higher rupture rates, and the need for more frequent stent placement (Arthur Miller et al., 2010; Sivananthan et al., 2014; Olin & Sealove, 2011). Cephalic arch lesions almost always recur and require repeated interventions.39 Angioplasty is often performed, but persistent stenosis is so frequent that it requires stent insertion. After a stent is installed, intrastent intima hyperplasia is often found which then leads to re-stenosis and FAV failure. Bennett et al.'s (2015) hypothesis is that the biological character of the vessels and the type of stenosis that occurs differ in the four domains. This concept is also seen in other vascular trees such as the renal artery. If stenosis occurs in the renal artery of the proximal section, the cause is often atherosclerosis. In contrast, distal lesions are usually caused by fibromuscular dysplasia. Optimal treatment may vary depending on the affected domain (Olin & Sealove, 2011).

In this study, after adjusting for confounding variables through multivariate analysis, the location of cephalic arch stenosis had no independent effect on angioplasty success and patency at 3 and 6 months post-angioplasty. Therefore, it is advisable to conduct intervention tests for each domain. By continuously evaluating cases of cephalic arch stenosis based on specific domains, it is hoped that it will be possible to determine whether certain domains are more susceptible to certain pathologies such as thrombus, as well as whether certain domains provide a better response to certain therapies.

**Weaknesses of the research**

Numerous confounding factors and small sample counts may affect the strength of this study. Independent variables and many confounding factors can reduce the strength of the study because each variable/predictor in the regression model uses a low degree of freedom and events-per-variable (generally about 10 events per variable studied). With underpowered research, random variation, and selection bias, it can affect the success rate of angioplasty patency rates.

## CONCLUSION

This study concluded that stenosis location, age, sex, degree and length of stenosis, cephalic arch insertion angle, number of balloons used, balloon size and pressure, balloon type, stent use, as well as histories of hypertension and diabetes were not significantly associated

with residual stenosis, 3-month patency, or 6-month patency after angioplasty in patients with cephalic arch stenosis. Despite these non-significant associations, angioplasty demonstrated a high technical success rate of 91.2%, with patency rates of 87.1% at 3 months and 66.7% at 6 months. These findings suggest that angioplasty remains an effective intervention for cephalic arch stenosis, although long-term patency remains a challenge. Future research is recommended to involve larger multicenter cohorts with longer follow-up periods and to explore additional biological and hemodynamic factors, including vessel wall characteristics and inflammatory markers, which may better explain restenosis and long-term access failure.

**REFERENCE**


Abdelsalam, H. (2022). Cephalic arch stenosis in autologous hemodialysis fistula; to stent or not to stent? Long-term follow up. *Egyptian Journal of Radiology and Nuclear Medicine*, *53*(1), 96.

Aftab, S. A., Tay, K. H., Irani, F. G., Gong Lo, R. H., Gogna, A., Haaland, B., et al. (2014). Randomized clinical trial of cutting balloon angioplasty versus high-pressure balloon angioplasty in hemodialysis arteriovenous fistula stenoses resistant to conventional balloon angioplasty. *Journal of Vascular and Interventional Radiology*, *25*(2), 190–198. https://doi.org/10.1016/j.jvir.2013.10.022

Alwi, A., Suhartono, R., & Kakalih, A. (2021). *Analisis faktor risiko yang berpengaruh terhadap keberhasilan tindakan single balloon angioplasty pada penderita stenosis vena sentral*. Universitas Indonesia Publishing.

Arasu, R., Jegatheesan, D., & Sivakumaran, Y. (n.d.). *Overview of hemodialysis access and assessment*. [Publisher not identified].

Arthur Miller, G., Friedman, A., Khariton, A., Preddie, D. C., & Savransky, Y. (2010). Access flow reduction and recurrent symptomatic cephalic arch stenosis in brachiocephalic hemodialysis arteriovenous fistulas. *Journal of Vascular Access*, *11*(4), 281–287. https://doi.org/10.5301/JVA.2010.5782

Badan Penelitian dan Pengembangan Kesehatan. (2018). *Laporan nasional Riskesdas 2018*. Kementerian Kesehatan Republik Indonesia.

Beathard, G. A. (2002). Angioplasty for arteriovenous grafts and fistulae. *Seminars in Nephrology*, *22*(3), 202–210. https://doi.org/10.1053/snep.2002.31748

Bennett, S., Hammes, M. S., Blicharski, T., Watson, S., & Funaki, B. (2015). Characterization of the cephalic arch and location of stenosis. *Journal of Vascular Access*, *16*(1), 13–18. https://doi.org/10.5301/jva.5000284

Besarab, A., Sullivan, K. L., Ross, R. P., & Moritz, M. J. (1995). Utility of intra-access pressure monitoring in detecting and correcting venous outlet stenoses prior to thrombosis. *Kidney International*, *47*(5), 1364–1373. https://doi.org/10.1038/ki.1995.193

Bountouris, I., Kritikou, G., Degermetzoglou, N., & Avgerinos, K. I. (2018). A review of percutaneous transluminal angioplasty in hemodialysis fistula. *International Journal of Vascular Medicine*, *2018*, Article 1420136. https://doi.org/10.1155/2018/1420136

Cakir, S., Guzelbey, T., Mutlu, I. N., & Kilickesmez, O. (2022). Comparison of functional patency rates between paclitaxel-eluting versus plain balloon angioplasty in hemodialysis patients with central venous stenosis: An intra-individual comparison study. *Therapeutic Apheresis and Dialysis*, *26*(1), 185–190. https://doi.org/10.1111/1744-9987.13638

Daoui, R., & Asif, A. (2012). Cephalic arch stenosis: Mechanisms and management strategies. *Seminars in Nephrology*, *32*(6), 538–544. https://doi.org/10.1016/j.semnephrol.2012.10.007

Dhingra, R. K., Young, E. W., Hulbert-Shearon, T. E., Leavey, S. F., & Port, F. K. (2001). Type of vascular access and mortality in U.S. hemodialysis patients. *Kidney International*, *60*(4), 1443–1451. https://doi.org/10.1046/j.1523-1755.2001.00947.x

Echefu, G., Shivangi, S., Dukkipati, R., Schellack, J., & Kumbala, D. (2023). Contemporary review of management techniques for cephalic arch stenosis in hemodialysis. *Renal Failure*, *45*(1). https://doi.org/10.1080/0886022X.2023.2196019

Eknoyan, G., Lameire, N., Eckardt, K., Kasiske, B., Wheeler, D., & Abboud, O. (2012). *KDIGO 2012 clinical practice guideline for the evaluation and management of chronic kidney disease*. International Society of Nephrology. https://www.publicationethics.org

Jaberi, A., Schwartz, D., Marticorena, R., Dacouris, N., Prabhudesai, V., Mcfarlane, P., et al. (2007). Risk factors for the development of cephalic arch stenosis. *Journal of Vascular Access*, *8*(4), 287–295.

Kian, K., & Asif, A. (2008). Cephalic arch stenosis. *Seminars in Dialysis*, *21*(1), 78–82. https://doi.org/10.1111/j.1525-139X.2007.00392.x

Kim, Y., Kim, H. D., Chung, B. H., Park, C. W., Yang, C. W., & Kim, Y.-S. (2022). Clinical predictors of recurrent cephalic arch stenosis and impact of the access flow reduction on the patency rate. *The Journal of Vascular Access*, *23*(5), 718–724.

Kitrou, P. M., & Karnabatidis, D. (n.d.). *Endovascular treatment of dysfunctional vascular access: From fundamentals to an algorithmic approach*. [Publisher not identified].

Lok, C. E., Huber, T. S., Lee, T., Shenoy, S., Yevzlin, A. S., Abreo, K., et al. (2020). KDOQI clinical practice guideline for vascular access: 2019 update. *American Journal of Kidney Diseases*, *75*(4), S1–S164. https://doi.org/10.1053/j.ajkd.2019.12.001

Luyckx, V. A., Tonelli, M., & Stanifer, J. W. (2018). The global burden of kidney disease and the sustainable development goals. *Bulletin of the World Health Organization*, *96*(6), 414–422D. https://doi.org/10.2471/BLT.17.206441

Muradi, A., Firdhianto, D., & Kekalih, A. (2019). Factors related to the success of endovascular therapy with plain old balloon angioplasty of central vein stenosis in haemodialysis patients. *Journal of Indonesian Society for Vascular and Endovascular Surgery*, *1*(1), 6–9. https://doi.org/10.51559/jisvs.v1i1.2

Olin, J. W., & Sealove, B. A. (2011). Diagnosis, management, and future developments of fibromuscular dysplasia. *Journal of Vascular Surgery*, *53*(3), 826–836.e1. https://doi.org/10.1016/j.jvs.2010.10.066

Olsson, L. F., Odselius, R., Ribbe, E., & Hegbrant, J. (2001). Evidence of calcium phosphate depositions in stenotic arteriovenous fistulas. *American Journal of Kidney Diseases*, *38*(2), 377–383. https://doi.org/10.1053/ajkd.2001.26107

Pisano, U., Stevenson, K., Kasthuri, R., & Kingsmore, D. (2024). Cephalic arch stenosis: an analysis of outcome by type of first intervention. *CVIR Endovascular*, *7*(1), 13.

Rajan, D. K., Clark, T. W. I., Patel, N. K., Stavropoulos, S. W., & Simons, M. E. (2003). Prevalence and treatment of cephalic arch stenosis in dysfunctional autogenous hemodialysis fistulas. *Journal of Vascular and Interventional Radiology*, *14*(5), 567–573. https://doi.org/10.1097/01.RVI.0000071087.76348.6B

Remuzzi, A., & Ene-Iordache, B. (2013). Novel paradigms for dialysis vascular access. *Clinical Journal of the American Society of Nephrology*, *8*(12), 2186–2193. https://doi.org/10.2215/CJN.03650413

Sarala, S., Sangeetha, B., Mahapatra, V. S., Nagaraju, R. D., Kumar, A. C. V., Lakshmi, A. Y., et al. (2018). Cephalic arch stenosis: Location of stenosis in Indian hemodialysis patients. *Indian Journal of Nephrology*, *28*(4), 273–277. https://doi.org/10.4103/ijn.IJN_204_17

Schwab, S. J., Raymond, J. R., Saeed, M., Newman, G. E., Dennis, P. A., & Bollinger, R. R. (1989). Prevention of hemodialysis fistula thrombosis. Early detection of venous stenoses. *Kidney International*, *36*(4), 707–711. https://doi.org/10.1038/ki.1989.248

Shemesh, D., Goldin, I., Zaghal, I., Berlowitz, D., Raveh, D., & Olsha, O. (2008). Angioplasty with stent graft versus bare stent for recurrent cephalic arch stenosis in autogenous arteriovenous access for hemodialysis: A prospective randomized clinical trial. *Journal of Vascular Surgery*, *48*(6), 1524–1531.e2. https://doi.org/10.1016/j.jvs.2008.07.071

Sivananthan, G., Menashe, L., & Halin, N. J. (2014). Cephalic arch stenosis in dialysis patients: Review of clinical relevance, anatomy, current theories on etiology and management. *Journal of Vascular Access*, *15*(3), 157–162. https://doi.org/10.5301/jva.5000196

Tantinius, S., Suhartono, R., & Pakasi, T. (2023). *Faktor yang berpengaruh terhadap primer patensi 6 dan 12 bulan pasca single balloon angioplasty pada stenosis vena sentral pasien gagal ginjal kronik*. Universitas Indonesia Publishing.

Tirinescu, D. C., Bondor, C. I., & Kacso, I. M. (n.d.). Hierarchy of risk factors for stenosis of arteriovenous fistula in chronic hemodialysis patients using TOPSIS method. *Veterinary Medicine International Journal of the Bioflux Society*. http://www.hvm.bioflux.com.ro/

Tripsianis, G., Christaina, E., Argyriou, C., Georgakarakos, E., Georgiadis, G. S., & Lazarides, M. K. (2021). Network meta-analysis of trials comparing first line endovascular treatments for arteriovenous fistula stenosis. *Journal of Vascular Surgery*, *73*(6), 2198–2203.e3. https://doi.org/10.1016/j.jvs.2020.11.029

Turmel-Rodrigues, L., Pengloan, J., Baudin, S., Testou, D., Abaza, M., Dahdah, G., et al. (2000). Treatment of stenosis and thrombosis in haemodialysis fistulas and grafts by interventional radiology. *Nephrology Dialysis Transplantation*, *15*(12), 2029–2036. https://doi.org/10.1093/ndt/15.12.2029

Vaidya, S., & Aeddula, N. (2024). Chronic kidney disease. *StatPearls*. StatPearls Publishing.

Verstandig, A., & Shemesh, D. (2012). Managing cephalic arch stenosis. *Endovascular Today*, 63–65.

Woods, J. D., Turenne, M. N., Strawderman, R. L., Young, E. W., Hirth, R. A., Port, F. K., et al. (1997). Vascular access survival among incident hemodialysis patients in the United States. *American Journal of Kidney Diseases*, *30*(1), 50–57. https://doi.org/10.1016/S0272-6386(97)90564-0

Xue, J. L., Dahl, D., Ebben, J. P., & Collins, A. J. (2003). The association of initial hemodialysis access type with mortality outcomes in elderly Medicare ESRD patients. *American Journal of Kidney Diseases*, *42*(5), 1013–1019. https://doi.org/10.1016/j.ajkd.2003.07.004