Factors That Influence Patency of Post-Endovascular Fistula Salvage Procedure in Arteriovenous Fistula Dysfunction

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Introduction: Beyond the primacy of arteriovenous fistulas (AVF) as hemodialysis access, AVF is not always free of problems. Although the incidence of stenosis and thrombosis is low, these two obstacles can still occur. The development of endovascular fistula salvage (EFS) procedures can be a solution for non-immature AVF, stenosis, or thrombosis for functional return. There are limited factors known to support the success of EFS in patients with characteristics that exist in Indonesia.

Method: People with AVF dysfunction (n = 107) performed by EFS were evaluated in a retrospective cohort between November 2015 and November 2017 to obtain a picture of post-EFS patency and was assessed for the relationship between anatomic variation, diabetes mellitus, and patient age with post-EFS AVF patency.

Results: There were 133 stenoses with 66 stenoses in juxta anastomosis, 7 in feeding arteries, and 60 in draining vein fistula. The average length of the stenosis is 21.5 mm. Residual stenosis of more than 30% was found in 21 cases (15.8%). Variables that affected dysfunction were age (p = 0.038) and diabetes (p = 0.035). In this study, it was found that multiple stenoses also affected primary patency (p = 0.008). Primary patency in the first 6 months and 12 months was 82.2% and 74.8%, respectively. Complications were found in 8 cases (7.47%).

Conclusion: EFS procedure on dysfunctional AVF can be the first choice compared to new AVF creation actions or heavenly revision actions.

Keywords: endovascular fistula salvage, arteriovenous fistula dysfunction, percutaneous transluminal angioplasty

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INTRODUCTION

The success of dialysis is directly related to whether or not the dialysis is adequate, which is substantially dependent on the dialysis access. Today, hemodialysis vascular access and all its problems are still one of the causes of hospitalization and stage 5 morbidity in patients (CKD).¹

Several studies have shown that the use of arteriovenous fistula (AVF) has reduced the morbidity and mortality of CRF patients.¹⁻³ Guidelines from the National Kidney Foundation Dialysis Outcome Quality Initiative (NKF-DOQI) recommend the creation of natural AVF with the first choice are snuffbox fistula and radiocephalic fistula followed by brachiocephalic then brachobasilic fistula. If unable to carry out various causes, the choice is arteriovenous graft (AVG). NKF-DOQI initiated the Fistula First campaign with a target of using AVF reaching 65% in 2009.^{1,2,4}

One of the objectives of the campaign is to avoid using catheters as hemodialysis access. The guidelines stated that natural AVF has a low thrombosis rate, does not require much intervention, and supports the long-term success of vascular access. Furthermore, it is said that the costs required for the creation of AVF and its maintenance proved to be the cheapest compared to other available dialysis access.^{3,5}

However, AVF access is not always free of problems. Although the stenosis and thrombosis rates are lower than AVG, these two obstacles can still occur in AVF, especially in patients who are not appropriately monitored. AVF dysfunction is associated with morbidity, mortality, and increased burden of hemodialysis access costs.⁶ Only 26-58% of AVF remains functional without intervention within 12 months.⁷

At present, when dysfunction is found from an AVF, it is generally responded by making a new

AVF so that the patients get new problems. Patients must undergo surgery, and they must return to use a catheter while waiting for the AVF maturation, and return to exposure to the main problems of the catheter in the form of infection rates and high stenosis. Central venous stenosis is a complication of catheter placement, which is still a frustrating condition for many vascular experts due to the recurrent management of recoil and restenosis. In patients who do not already have ideal blood vessels for new AVF, they are forced to create AVG, where AVG is more susceptible to infection leads to failing catastrophically as hemodialysis access. Several studies show that the creation of new AVF acts has a greater cost than the intervention of endovascular fistula salvage due to a large number of additional procedures and even the endovascular actions of the new AVF to ensure maturation.⁸ The need for interventions, especially new surgery for patients with the condition of low immunity due to chronic kidney disease, causes increased hospital stay and increases morbidity and mortality rates.^{9,10} It is, therefore, imperative for vascular specialists to adopt new ways and strategies to minimize morbidity and maximize the quality of life of patients undergoing hemodialysis.

The development of endovascular procedures is auspicious to be a solution for non-immature AVF, stenosis, or even thrombosis to be functional again.^{11,12} Tan et al. said that endovascular intervention in the form of balloon angioplasty is a procedure that had proven to be safe and effective in the management of AVF dysfunction.^{12,13} Although endovascular fistula salvage (EFS) has become the main treatment in many vascular service centers, post-action patency rates still vary greatly.⁷ Many studies abroad discuss the effectiveness of EFS measures and examine the factors that support success as reflected by patency from the AVF; however, there have not been many studies of EFS in Indonesia, and there are limited factors that known to support the success of EFS with patients. The factors that influence patency is expected to help vascular specialists decide whether a case requires an EFS procedure in AVF dysfunction or is likely to choose another modality.

METHOD

This study was conducted with a retrospective analytic cohort design to obtain a picture of post-EFS patency and assess the relationship between anatomic variations, underlying diabetes mellitus, and patient age on post-EFS AVF patency.

Inclusion criteria are (1) men or women aged 15-70 years who undergo the EFS procedure, (2) no history of previous AVF dysfunction, (3) total Blood Flow access is less than 500 ccs/minute, (4) reduction in blood flow of more than 20% from the baseline, (5) blood flow data previously added to one of the following conditions: fistula recirculation >5%, difficult cannulation, peak systolic high pressure or dynamic venous pressure that exceeds the threshold and is measured in at least three times the measurement, clinical sign or other hemodynamic signs that indicate the possibility of AVF dysfunction include variable hemodialysis machine speeds, swollen arms, and arm pain. Exclusion Criteria were (1) stage 5 CKD patients who used AVG access, (2) stage 5 CKD patients with AVF access that had never been declared mature and had never been used for hemodialysis access, (3)

patients with AVF dysfunction due to central venous stenosis

Data were analyzed with SPSS® 20.0 with descriptive analysis assessed the characteristics and distribution of age, sex and primary disease, AVF type, location of the stenosis, comorbid diabetes mellitus, and access to intervention. The relationship of demographic data and clinical factors on the duration of patency was evaluated by Kruskal-Wallis and Mann-Whitney method. A multivariate logistic regression test analyzed the relationship of patient age variables, comorbid diabetes mellitus, multiple conditions of stenosis, and residual stenosis to the duration of patency.

RESULTS

Patient data were collected, including demographic characteristics, causes of chronic kidney disease, type of AVF, the side made of AVF, presence of diabetes mellitus, access location used in angioplasty, and location of stenosis found (table 1). The mean age of patients was 52.1±17.3 years. Sex distribution was more prevalent in males than females, with 56.1% and 43.9%, respectively. The most common cause of kidney failure is due to diabetes mellitus (57%) and hypertension (21.5%). The most common type of AVF is brachiocephalic (49.5%), followed by radiocephalic (47.7%), and brachobasilic acid (2.8%). The AVF location was more in the left arm (83.2%) than in the right (16.8%). In this study, 70 people (65.4%) had comorbid diabetes.

The access used for the most angioplasty procedure (figure 1) was the brachial artery (46%) followed by the femoral artery (21%), draining vein (22%), and radial artery (11%). In this study with angiography found 133 stenoses, 66 stenoses found in juxta-anastomosis, 7 in arterial feeding, and 60 in draining vein fistula. The average length of stenosis is 21.5 mm (median, 11 mm in the range 1-127 mm), the mean degree of stenosis is 91.5% (median 92.5% in the range of 52-98%).

We found 16 (14.9%) cases with total AVF occlusion (figure 2). There were 4 cases (3.7%) with procedure failure where stenosis was impenetrable. EFS was technically successful in 112 stenoses (84.2%) (n=133). Residual stenosis of more than 30% was found in 21 cases (15.8%). The degree of residual stenosis found in groups that were not considered technical success ranges from 31-51%. Clinical success was found in 92.4% of cases (n=133).

Complications occurred in 8 procedures in which there were 2 cases with rupture of draining vein, 2 cases of pseudoaneurysm in access, 3 cases with hematoma, 1 case with arterial feeding thrombosis.

The mean follow-up time was 15.2 months (13.90-16.42 months), AVF remained patent for 50 (46.7%) patients for the entire follow-up (23 months). Short-term recurrences were found in 19 cases (17.8%). Long-term recurrences were found in 8 cases (8.1%).

Table 2 shows the relationship between demographic variables and clinical factors on patency. Variables that influence short-term dysfunction are age (p=0.038) and diabetes (p=0.035). In this study,

Table 1. Patients and fistula characteristics

Variable	n = 107
Age (years)	52.1 ± 17.33
Gender	
Male	60 (56.1)
Female	47 (43.9)
Cause of CKD	
Hypertension	23 (21.5)
Diabetes mellitus	61 (57.0)
Nephrolithiasis	6 (5.6)
Renal cyst	8 (7.5)
Glomerulonephritis	4 (3.7)
Unknown	5 (4.7)
Type of AVF	
Brachio basilica	3 (2.8)
Brachiocephalica	53 (49.5)
Radiocephalica	51 (47.7)
Side of AVF	
Right	18 (16.8)
Left	89 (83.2)
Diabetes	70 (65.4)
Location of stenosis	
Juxtaanastomosis	66 (61.7)
Draining vein	34 (31.8)
Feeding artery	7 (6.5)
Patency	
6 months	88 (82.2)
12 months	80 (74.8)

it was found that multiple stenoses also affected primary patency ($p = 0.008$).

patency rates and high short-term recurrence stenosis and long-term.

Figure 1. Location of intervention access. **Figure 2.** EFS results in AVF with total occlusion.

Primary patency in the first 6 months and 12 months was 82.2% and 74.8%. Table 3 shows the relationship between patient age, diabetes mellitus, the presence of multiple stenoses, and residual stenosis to primary patency analyzed with the multivariate test. It was found in old age, the presence of diabetes mellitus, and the presence of multiple stenoses are associated with low primary

Figure 3. Survival chart of AV fistula patency at 23-month follow-up.

DISCUSSION

In this study, a retrospective cohort analysis of the predictor factors affecting post-EFS patency rates was performed in patients with dysfunctional AVF. Overall, EFS in AVF dysfunction was found to have a high success rate both technically and clinically. Patient age, diabetes mellitus, and the presence of multiple stenoses were factors that influence short-term recurrent stenosis.

Align with other literature; in this study, it was found that the most location of the stenosis was juxta anastomosis 66 (49.6%). The stenosis degree in this study was a median of 92.5%, with a mean value of 91.5%. It was different from a study by Heye

Table 2. Relationship of demographic variables and clinical factors on patency

Variable (n)	Primary patency		Patency duration (months)	Log Rank	p
	6 months	12 months			
Age				9.778	0.019 ^{kw}
<65 years (n=88)	85.2	79.5	18.38 (17.67-19.09)		
65-75 years (n=13)	69.2	46.2	17.89 (15.78-20.02)		
>75 years (n=6)	66.7	66.7	18.09 (14.92-21.26)		
Gender				1.331	0.406 ^{mw}
Male (n=60)	80.0	71.7	15.1 (13.32-16.79)		
Female (n=47)	85.1	74.8	15.3 (13.39-17.18)		
Diabetes				4.455	0.017 ^{mw}
Yes (n=70)	75.9	64.8	14.0 (12.02-15.98)		
No (n=37)	88.7	84.9	16.3 (14.78-17.88)		
Stenosis location				1.638	0.173 ^{kw}
Juxta anastomosis (n=66)	80.3	69.7	15.2 (13.44-16.87)		
Draining vein (n=34)	85.3	85.3	14.67 (12.56-16.78)		
Feeding artery (n=7)	85.7	71.4	17.49 (12.60-22.39)		
Multiple stenosis				7.007	0.008 ^{mw}
Yes (n=27)	70.4	63.0	12.02 (8.75-15.29)		
No (n=80)	86.3	78.8	16.21 (14.97-17.45)		
In general*	82.2	74.8	15.2 (13.90-16.42)	n/a	n/a

*All demographic variables are evaluated together

^{mw}Data was analyzed by the Mann-Whitney U analysis method

^{kw}Data were analyzed by the Kruskal-Wallis analysis method

Table 3. Relationship between patient age, diabetes mellitus, the presence of multiple stenoses, and residual stenosis with primary patency based on logistic regression tests.

Variable	Odds Ratio	95% CI	p
Age	1.020	0.989 – 1.052	0.210
Diabetes mellitus	2.641	0.989 – 7.050	0.053
Multiple stenosis	1.840	0.681 – 4.973	0.229
Residual stenosis	1.842	0.368 – 9.229	0.457

et al.¹⁴ with a degree and a median of 71% and 72.2%, respectively. The average length of stenosis was 21.5 mm (median 11 mm with a range of 1-127 mm). This result was similar to some other literature studies. There was no effect of gender, AVF side, AVF type, and location of stenosis on patency.¹⁵ In this study, multiple stenoses were found to significantly affect patency ($p=0.008$), where this result was different from some literature where it was said that the condition of multiple stenoses was not related to patency. This could be due to logistical limitations on the actions of angioplasty undertaken related to balloon angioplasty covered by health insurance only limited to one balloon angioplasty and always prioritized for the main stenosis. For stenosis in other locations, often the size of the balloon is not appropriate so that residual stenosis remains high.

The most common cause of AVF dysfunction is venous stenosis. The pathogenesis of venous stenosis cannot be explained thoroughly and is a complex process. Cellular proliferation, the formation of micro blood vessels, and the release of cytokines by macrophages, endothelial cells, and smooth muscle cells are considered the most responsible for the pathophysiology of venous stenosis. Cytokines initiate activation and proliferation of smooth muscle cells and endothelial cells and macrophages with the result of the emergence of neointimal hyperplasia.¹⁶ When stenosis exceeds 50% (hemodynamically significant), the efficiency of dialysis is considerably reduced so that thrombosis can occur if treatment is not prompt. So early diagnosis of the condition of stenosis in access and management is also crucial early.

In this study, age, diabetes, and the presence of multiple stenoses were found to have a significant effect on primary patency. As the patient's

age increases, the duration of primary patency becomes shorter ($p=0.038$). In people with diabetes, the mean value of primary patency duration was 14.0 months whereas in patients without diabetes the duration of primary patency was 16.3 months ($p=0.035$).

The complication rate in this study was found to be 7.47%. This result was not aligned with the complication rate from several other studies, which mentioned the 3.7% rate.^{14,17}

CONCLUSION

The dysfunctional arteriovenous fistula condition can be safely maintained with continuity of follow-up and repeated intervention. EFS action on dysfunctional AVF can be the first choice compared to new AVF creation actions or heavenly revision actions. Thus, further studies are needed to assess long-term patency, such as 2 to 5 years.

CONFLICT OF INTEREST

The author states the original work, and there is no conflict of interest in doing this research.

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