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Long-Term Patency of Arteriovenous Fistula After Endovascular Salvage Procedure and Its Affecting Factors

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Abstract

Introduction. The limited durability of vascular access referred to the great challenges in hemodialysis. An immature arteriovenous fistula (AVF) that inadequately develops to support dialysis noted as the leading cause to immature AVF if stenosis found after creation. The endovascular fistula salvage (EFS) addressed for the preemptive repair of immature AVF despite surgical revision. However, no study on EFS proceeded in Indonesia with its specific characteristics. Thus, this study aimed to evaluate the efficacy of EFS and its influencing factors.

Method. A retrospective cohort study carried out on those with immature AVF who underwent EFS procedures during the period of January 2016 to December 2016. The primary patency after EFS was assessed in correlation to subjects' characteristics, anatomical variations, diabetes mellitus, and the length and diameter of balloon to post EFS patency

Results. There was 125 stenosis noted, a total of 66 stenoses noted in juxta anastomosis. The average length of stenosis was 33.18 mm. Age, diabetes mellitus, length of stenosis and multiple stenoses were found as the influencing factors to the primary patency. The length of stenosis was the most influencing variable in 6 months primary patency ($p < 0.001$), with the cut-off point of the diameter at 35 mm. Multiple stenoses ($p < 0.001$) was the most important factor influencing on 12 months of primary patency. The length and diameter balloon were not influencing the primary patency on 6 months and 12 months. Overall primary patency in 6 months and 12 months was 69.3% and 38.6%, respectively.

Conclusion. EFS procedures on immature AVF may be applied as the first method of choice in treatment, compared to new AVF creation or surgical revision.

Keywords: *endovascular salvage fistula, immature arteriovenous fistula, percutaneous transluminal angioplasty*

Introduction

The success of dialysis directly correlated to the adequacy of access that substantially depends on the quality of the access. The most challenging issue in hemodialysis is the limitation of vascular access with good resistance. In the United States, the total costs spent on improving vascular access were estimated to reach up to 2.9 trillion USD, which is a total of 15% hemodialysis care.¹

Those with chronic renal failure (CRF) maintain their lives with routine hemodialysis. Therefore, for an optimal hemodialysis result, good vascular access is required. Out of the various permanent access, arteriovenous fistula (AVF) referred to a method of choice. Based on data released by the Indonesian Renal Registry (2012), the incidence of patients with CRF reaches up to 20,000 cases per year with diabetic nephropathy and hypertensive kidney disease as the main causes. According to the Indonesian Nephrology Association (PERNEFRI), about 83% of patients undergoing hemodialysis is end-stage renal disease patients (ESRD) which is a terminal stage of chronic kidney disease (CKD).¹

For hemodialysis, NKF-DOQI pointed out the native AVF as the best vascular access as it provides longer patency, lower infections, lower mortality and better patient quality of life. Therefore, providing adequate vascular access is a requirement to have success for

hemodialysis. A successful vascular access met if the "rules of six" were fulfilled, among others: the diameter of the draining vein which is more than 6 mm, the period of access to the fistula is more than 6 weeks, the blood flow is more than 600 mL/minute, and the distance from the skin is less than 6 mm.² In the other hand, a failed vascular access defined in the maturation process (or, immature) as there is a thrombosis found in the access before the use or difficult to be used for hemodialysis purpose, the diameter of the draining vein is not achieved in a month after creation, difficult for cannulation, and blood flow less than 350 mL/minute.^{8,24}

To increase the prevalence of AVF, there is an increasing number (up to 28–60%) of native fistulas that failed to maturation to facilitate hemodialysis. Therefore, the efforts to save the primary fistulas is important to increase the prevalence of AVF.

Stenosis referred to the most common cause of the AVF failure, which is commonly found in arterial, anastomosis of artery and veins, juxta anastomosis, throughout the draining vein, or in the central vein. However, the management of stenosis is often delayed were mostly patients come to follow-up with manifested problems during hemodialyses such as cannulation difficulties, venous thrombosis, and recirculation. Even though the procedure of surgical revision is succeeded, the draining vein will be then shorter and somehow minimizing cannulation area.²

The procedure of endovascular fistula salvage (EFS) with balloon angioplasty (BA) is a procedure to address the problem of stenosis, both in central- and peripheral veins. To treat an AVF stenosis, the outpatient procedure may be applied, and the access can immediately be used following successful correction. With such a procedure, lesions in all parts of arteriovenous access and draining veins, both peripheral and central, can be safely and effectively treated.³ The procedures showed advantages such as minimal blood loss, no hospitalization required, and minimal pain. The procedure introduced in 1980 and to date is widely applied. However, in Indonesia, such a procedure proceeded in the vascular and endovascular division in dr. Cipto Mangunkusumo commenced in 2013, but no evaluation had been made. Although the effectiveness of EFS for AVF dysfunction has been published, the salvaging procedure of AVF that failed to maturation remains minimal.

In addition to surgery, the modality to treat the AVF maturity failure is BA, but existing reports both retrospective and prospective remains limited. There were studies showed that BA improves and increases the survival rate of AVF access. Although EFS has become the main management in many vascular centers, the rate of patency remains in vary.⁷ Many studies focused on the effectiveness of EFS and reviewed the factors influencing the success and patency of AVF dysfunction, however, study on EFS to treat the failure of maturation of AVF in Indonesia referred to nil. The factors known to affect the success of EFS in Indonesian characteristics have never been reported. Thus, we conducted a study that aimed to determine the mean primary patency and factors that influence the management of the failure of AVF maturation.

Method

A retrospective cohort study conducted to obtain post-EFS patency and assess the correlation of influencing factors including age, anatomic variation, diameter and length of a stenosis, and the correlation of the length of BA to AVF patency after EFS procedure. The target population was all patients diagnosed as AVF maturity failure (MF) treated by endovascular surgeon team of dr. Cipto Mangunkusumo General Hospital (CMGH). The affordable population was AVF MF patients treated in the division of vascular and endovascular surgery underwent BA, namely venography and venoplasty at the CMGH and surrounding hospital during the period of January 2016 to December 2016. A consecutive sampling method has been employed, namely all patients of CKD stage 5 with AVF MF who underwent EFS and meet the inclusion criteria: those with a failure due to stenosis after an establishment of AVF that found in 6–8 weeks prior to hemodialysis; proceeded the procedure BA, and those underwent the procedure of BA for the first time. Those with the swelling of the upper arm that is not related to AVF (lymphedema, neurofibroma, soft tissue tumors, etc.), post-venography found stenosis in the proximal of cephalic arch (central venous stenosis), AVF thrombosis, infected arteriovenous fistula, hypersensitivity to contrast, utilized AVF for hemodialysis prior to BA; those underwent balloon-assisted maturation with no stenosis; and those with CRF with AV graft were excluded.

Data were processed using SPSS 20.0 for Macintosh. The descriptive analysis was carried out to find out the characteristics and data distribution (age, sex and underlying disease, location of the stenosis, type of stenosis, length of a stenosis, balloon diameter and balloon length, results in the outcome of BA). These data expressed in percentage. Numerical data underwent a test for normality and descriptively described to obtain data on mean and

standard deviation (SD), or median (minimum-maximum). Categorical data proceeded statistical analysis using Chi-square or Fisher test. The patency survival proceeded by Kaplan Meier's analysis

Results

Data of subjects (demographic characteristics, etiology of chronic renal failure, type of AVF, locations of stenosis, the patency in 6 months and 12 months) were shown in table 1. Subjects' mean age was 58.45 years (± 2.84). Male to female ratio was 55.7%: 44.3%. The etiology of CKD was diabetes mellitus (51.1%) and hypertension (26.1%). Brachiocephalic type of AVF (50%) equal to radiocephalic (50%). The most site of stenosis based on ultrasound was at the junction area of anastomosis (64.7%), whereas using angiography it was found the sites of stenosis in 125 subjects were in an artery (five subjects), in the junction area (66 subjects) and in draining vein (54 subjects). Those with multiple stenoses found in 37 subjects (42%) and the primary patency of 6 months was 69.3% and 12 months was 38.6%.

Table 1. Subjects characteristics and the fistula

Variable	n (%)
Age (years)	58.45 \pm 2.84
Gender	
– Male	49 (55.7%)
– Female	39 (44.3%)
Etiology of CKD	
– Hypertension	23 (26.1%)
– Diabetes mellitus	45 (51.1%)
– Stones	6 (6.8%)
– Glomerulonephritis	3 (3.4%)
– Kidney Cysts	7 (8%)
– Unknown	4 (4.5%)
AVF type	
– Brachiocephalic	44 (50%)
– Radiocephalic	44 (50%)
Site of stenosis	
– Artery	2 (2.3%)
– Anastomosis junction	57 (64.7%)
– Draining vein	29 (33%)
Multiple stenoses	
– Yes	37 (42%)
– No	51 (58%)
Patency	
– 6 months	61 (69.3%)
– 12 months	38.6%

In the 6-months primary patency, the variables of age, diabetes mellitus, multiple stenosis and length of stenosis showed a significant correlation, while an oversize of the length and diameter of the balloon and the location of stenosis did not show a significant correlation. In the 12-month primary patency, the variables of diabetes mellitus, multiple stenosis and length of stenosis showed a significant correlation, while as age, gender, location, and oversize stenosis and diameter balloon showed no significant correlation. The factors that show a correlation to the 6-month primary patency underwent multivariate analysis using logistic regression and found that stenosis was correlated with a lower 6-month primary patency. The length of stenosis with a 35mm cut-off point showed a fairly good level of sensitivity and specificity that influencing the patency of 6 months where the length of stenosis was less than 25 mm, a more than 45 mm showing a low level of patency.

Focusing on survival analysis using Kaplan Meier test, it found that the survival rate was 8.875 months with 95% CI (8.158–9.592).

Table 2. Correlation between subjects' characteristic and 6 months patency

Variable	6 months patency		p	OR	95% CI
	No patency n (%)	Patency n (%)			
Age			0.008*		0.399–2.471
– <65	13 (22)	46 (78)			
– 65–75	7 (36.8)	12 (63.2)			
– >75	7 (70)	3 (30)			
Gender			0.987*	0.993	1.480–10.402
– Male	15 (30.6)	34 (69.4)			
– Female	12 (30.8)	27 (69.2)			
Diabetes mellitus			0.005*	3.924	0.659–4.442
– Yes	19 (45.2)	23 (54.8)			
– No	8 (17.4)	38 (82.6)			
Site of stenosis			0.268*	1.711	1.682–11.620
– Draining vein	11 (37.9)	18 (62.1)			
– Juxta	15 (26.3)	42 (73.7)			
Multiple stenoses			0.002*	4.421	4.935–53.777
– Yes	18 (48.6)	19 (51.4)			
– No	9 (17.6)	42 (82.4)			
Length of stenosis			<0.001*	16.291	
– >60 mm	16 (76.2)	5 (23.8)			
– <60 mm	11 (16.4)	56(83.6)			
Oversize					
– Length			0.496**		
– Diameter			0.324**		

* Chi-square test; ** Mann–Whitney test

Table 3. Correlation between subjects' characteristic and 12 months patency

Variable	6 months patency		P	OR	95% CI
	No patency n (%)	Patency n (%)			
Age			0.984*		
– <65	37 (62.7)	22 (37.3)			
– 65–75	12 (63.2)	7 (36.8)			
– >75	6 (60)	4 (40)			
Gender			0.868*	1.076	0.452–2.564
– Male	31 (63.3)	18 (36.7)			
– Female	24 (61.5)	15 (38.5)			
Diabetes mellitus			0.011*	3.200	1.281–7.994
– Yes	32 (76.2)	10 (23.8)			
– No	23 (50)	23 (50)			
Site of stenosis			0.142*	2.051	0.779–5.398
– Draining vein	21 (72.4)	8 (27.6)			
– Juxta	32 (56.1)	25 (43.9)			
Multiple stenoses			<0.001*	10.875	3.354–35.263
– Yes	33 (89.2)	8 (27.6)			
– No	22 (43.1)	25 (43.9)			
Length of stenosis			0.045*	3.243	0.985–10.678
– >60 mm	17 (81)	4 (19)			
– <60 mm	38 (56.7)	29 (43.3)			
Oversize					
– Length			0.568**		
– Diameter			0.408**		

* Chi-square test; ** Mann–Whitney test

Table 4. Logistic regression of factors associated with 6-month patency

	Variable	p	OR	95% CI
Stage 1	Age	0.462	0.454	0.056–1.586
	Diabetes mellitus	0.079	2.836	0.885–9.085
	Multiple stenosis	0.102	2.765	0.816–9.365
	Length of stenosis	0.004	7.053	1.842–27.003
Stage 2	Diabetes mellitus	0.088	2.686	0.863–8.363
	Multiple stenosis	0.184	2.187	0.690–6.934
	Length of stenosis	<0.001	10.418	2.915–37.234
Stage 3	Diabetes mellitus	0.076	2.766	0.899–8.513
	Length of stenosis	<0.001	13.622	4.018–46.181

Table 6. ROC Length of stenosis

Positive if greater than or equal to ^a	Sensitivity	Specificity
4.00	1.000	0.000
7.50	1.000	0.033
12.50	.778	0.328
17.50	.778	0.344
25.00	.704	0.623
35.00	.630	0.820
45.00	.630	0.885
55.00	.593	0.918
65.00	.333	0.951
75.00	.296	0.984
87.50	.111	0.984
97.50	.074	0.984
101.00	0,000	1.000



Discussion

In the study, a retrospective analysis of the predictor factors affecting the primary patency after EFS has been carried out in those with AVF who were maturing. Overall, it was found that EFS in matured AVF showing a high success rate both technically and clinically. Age, diabetes mellitus, multiple stenoses, and length of stenosis were factors influencing the 6-month patency. Meanwhile, in the study, both oversized diameter and length of the balloon was not a factor affecting the primary patency, both in 6 months and 12 months. This is consistent with previous studies showing an initial dysfunction (namely in 6 months) is affected by age, diabetes and stenosis length.^{19,20,22}

However, through a multivariate regression test, it was found that the most influential primary patency for 6-months was the length of stenosis and the one that most affected the primary patency of 12-months were multiple stenoses.

On this study, most stenoses found in the anastomosis 66 (52.8%). The mean length of stenosis was 33.18 mm (median 20 mm with a range of 5–100 mm), this is like other studies.²⁰ No influence of gender, site of AVF, type of AVF and sites of stenosis on the patency.²² On the study, the length of stenosis significantly influenced primary patency of 6-months ($p < 0.001$). This is thought to be related to hemodynamic shear stress which is an important factor in restenosis.²²

What's interesting about the length of stenosis that affects this patency by analyzing the length of stenosis ROC found a 35 mm cut-off point has good sensitivity and specificity to predict the likelihood of 6-

months primary patency of an AVF, which is above the probability of primary patency over 6-months ugly. This is consistent with several studies and a systemic review reporting the length of stenosis is more than 2cm (20mm) and there are those that say more than 40 mm have shorter patency.²²

Multiple stenoses influencing both of 6-months and 12-months primary patency ($p < 0.001$); in accordance with previous studies found that multiple stenoses have a higher risk of restenosis compared to single stenosis. There is no study explains this finding, probably because those studies enrolling small samples.^{15,17,22}

Stenosis referred to the most problem found in AVF maturing leading to dysfunction. To date, the development of venous stenosis has not been clearly understood. Inflammatory response with cells proliferation, cytokines and inflammatory mediators, the formation of micro-vessels formation, endothelial cells and smooth muscle involvement were thought to be responsible in the development of venous stenosis. Cytokines initiate the activation and proliferation of smooth muscle cells and endothelial cells resulted in the neointimal hyperplasia. If the stenosis exceeds 50% (hemodynamically significant), the efficacy of dialysis markedly reduced let the thrombosis developed as is not treated immediately. Thus, early diagnosis of the stenosis and early management is very important.

The limitation of this study is that the available data from the medical record is not always complete, for example, the length of stenosis data

is incomplete, especially in the case of multiple stenoses where the length of each stenosis is only listed in the length of initial stenosis or accumulation. The location of multiple stenoses is not specifically explained so that measurements can only be obtained in the data of multiple stenoses or not in one patient, and not all multiple stenoses have lengths and diameters of each stenosis. Regarding the use of balloons also cannot always be adjusted according to the theory between the diameter and length of stenosis with the diameter and length of the balloon because when doing this BA action is based on the availability of the tool when the action is taken. So that the quality of the results of this study is still suboptimal. However, the results of this study can be used as reference material for better future research.

Conclusion

Factors in the form of age, diabetes, multiple stenoses, and length of stenosis affect patency 6 months after EFS. With a length of 35 mm stenosis, it becomes cut off patency. Factors in the form of diabetes, stenosis and long stenosis affect patency 12 months after EFS, with multiple stenoses influencing the most dominant 12 months patency. The length and diameter of the balloon used in EFS have no relationship to patency both 6 months and 12 months. The failure of artery-venous-fistula Maturity failure can still be maintained safely through EFS action intervention and regular follow-up. EFS action on AVF maturity can be the first choice compared to new AVF creation actions or surgical revision measures.

Disclosure

Author disclose there was no conflict of interest.

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