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Scoring predictor for successful of arteriovenous fistulas as vascular access in hemodialysis patients: PAVAS score

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ABSTRACT

Introduction: The use of vascular access (AV-fistula) for long-term hemodialysis is still served as the primary choice. The fact that there is still a high rate of failure of arteriovenous fistulas procedure is one of the obstacles in the treatment of chronic kidney disease problems. This study aims to assess the risk factors for AV-fistula or AV-shunt failure and develop a risk scoring system for the failure of the AV-fistula procedure in patients with chronic kidney disease.

Methods: This study is a prospective study conducted at Dr. Soetomo Hospital, Surabaya, Indonesia. The analysis focuses on the risk factors for AV-fistula failure and performs a scoring order using multiple logistic regression methods.

Results: Based on this study, three variables were found to have significant values in determining the risk of AV-fistula failure scoring, namely local arterial condition ($p<0.1$), local venous condition ($p<0.1$), and arterial diameter ($p<0.1$). The scoring system for normal arteries, normal veins, and artery diameter >1.8 mm was scored 1. Scoring for veins and arteries with a history of puncture was 1. Arteries with stiff sensation with weak pulses and veins with a history of intravenous catheters scored 2.

Conclusion: The use of scoring based on parameters of arterial diameter, local venous condition, and local arterial condition becomes a scoring system for predictors of the risk of failure of the AV-shunt procedure, with three scoring categories, namely low risk (score 0-1), medium risk (score 2 -3), and high risk (score 4-5). This study is only a preliminary study for arteriovenous fistula scoring (PAVAS Score) due to the limited sample size so that a large-scale follow-up study is needed to assess the validity of the proposed PAVAS score.

Keywords: scoring system, aterio-venous fistula, hemodialysis, failure.

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INTRODUCTION

Chronic kidney disease is a pathophysiological process with multiple etiologies, resulting in progressive decline in renal function, and generally ending in renal failure. If the kidneys cannot function properly, there will be a buildup of metabolic waste substances in the body, causing toxic effects. Chronic kidney disease can develop rapidly or chronically, up to 2 - 3 months in more than 30-40 years.[1]

The Kidney Disease Outcome Quality Initiative (KDOQI) of the national kidney foundation (NKF) defines chronic kidney disease as damage to the kidney parenchyma with a decrease in the glomerular filtration rate (GFR) of less than 60 mL/min/1.73 m^2 for or more than 3 months and generally ends in renal failure.[2]

According to world data from World Health Organization (WHO) it is estimated that there are more than 1.4 million patients with chronic kidney disease who need renal replacement therapy (RRT), with an incidence of 8% and growing every year.[3]

Chronic renal failure is common, according to data from The United States Renal Data System (USRDS) in 2009, the prevalence is around 10-13%. In the United States the number reaches 25 million people, in Indonesia the prevalence is estimated at 12.5% or around 18 million people.[4]

One of the renal replacement therapy is hemodialysis. Although there are other alternative renal replacement therapies such as peritoneal dialysis and kidney transplantation, more chronic kidney disease (CKD) management appoints hemodialysis.[5,6] The number of CKD patients in Indonesia who underwent hemodialysis in 2002 was 2,077, increasing to 4,344 in 2006.[7] In 2012 9,161 patients who were active on dialysis and the number of new patients was 19,621, an increase in 2014, from11,689 active patients and 17,193 new patients. In 2014, from all patients undergoing hemodialysis, 95% underwent routine hemodialysis, meaning the role of access vascular is critical.[8]

Vascular access is required for hemodialysis. Vascular access is said to be ideal if it can be used for a long time as blood circulation access with minimal complications. An arteriovenous fistula is the most ideal vascular access of all available hemodialysis

access. If the arteriovenous fistula is successful, it can be used for a long time with low thrombosis and infection rates, less intervention, and low costs.[9] Based on data from the Indonesia Renal Registry, in 2014 there were various types of vascular access used for hemodialysis in Indonesia, 490,486 person using arteriovenous fistulas, 10,948 person using central venous catheters (jugular), 28,999 person using central venous catheters (subclavian), 3,416 person using central venous catheters (femoral), and 144,270 person using femoral punctures. The use of continuous ambulatory peritoneal dialysis (CAPD) in 2014 was 1,423 person.[8]

The fact that there is still a high rate of failure in procedure of an arteriovenous fistula. Complications from vascular access are the most common causes of failure and hospitalization in dialysis patients. All the complicating factors for hemodialysis in Indonesia in 2014, access problems also included as many as 3,203 complications (3.25%) from total of 98,520 patients.[8] Limited data to understand complications of arteriovenous fistulas, especially stenosis and thrombosis, also hinder the success of the arteriovenous fistula technique.[12]

Patient evaluation is necessary to determine the placement of vascular access.[2] History of central venous catheter insertion was associated with central venous stenosis in 7% in one retrospective study in 150 patients.[13] History of diabetes mellitus is associated with vascular damage. History of peripheral access to either arterial or venous causes the target blood vessels to be damaged. Previous failed history of vascular access use affects subsequent vascular access plans because usually the cause of failure remains. A history of trauma to the arm, neck or thoracic region resulting in damage to blood vessels with a consequences of limited vascular access.[2]

According to a study conducted by Robbin et al. in fistulas with a diameter of more than 0.4 cm, 89% were successful and 11% failed. In fistulas less than 0.4 cm in diameter, 44% were successful and 56% were failed.

The cause of a failed arteriovenous fistula consists of two main factors which are inflow problems and outflow problems. Inflow problems include problems with the arteries such as small blood vessels and the presence of atherosclerotic disease. While the problem with the outflow mainly located in the veins, where the veins experience fibrosis, and also the small size of the veins.[15]

The success of arteriovenous fistulas is also influenced by the location of the fistula manufacture, according to the study of Roozbeh et al. that the success rate and fistula resistance are superior to brachiocephalic than radiocephalic (1 year and 3 year patency rates are 95% and 85% for those in brachiocephalic and 88% and 72% for those in radioephalic). Kazemadeh et al. statistically significant, namely with a value of p=0.023, which means that more men are successful than women. Also, according to Miller et al. fistula patency was better in men than women (31% vs. 51%, p=0.001).

On the facts described previously, it is necessary to conduct an evaluation through a study to see the factors that affect the success of arteriovenous fistulas, so that the factors that cause failure can be estimated and can be prevented.

METHOD

This study is a prospective study, evaluating stage V chronic renal failure patients who underwent arteriovenous fistulas as vascular access for routine hemodialysis. This research was conducted at Dr. Soetomo General Hospital Surabaya, Indonesia during the period February 2015 to January 2016. The population in this study were patients with stage V chronic kidney disease who underwent routine hemodialysis and arteriovenous fistula surgery.

The inclusion criteria of this study were patients with stage V chronic renal failure, who had routine hemodialysis or had planned for routine hemodialysis. While the exclusion criteria in this study were patients with poor general condition and unable to proceed for arteriovenous fistula surgery. The variables in this study were age, gender, hypertension, diabetes mellitus, comorbid vascular disease, local artery condition, local vein condition, arterial diameter, and venous diameter. The patency of the graft was assessed with an OQb blood flow rate of 150-300 and the mean hemodialysis speed of machine rotation (Qd) was 500.

The data analysis in this study using SPSS version 25.0, multiple logistic regression tests were performed to assess the risk factors that play a role in the failure of AV-fistula procedure and perform a scoring model of these results.

RESULT

Characteristics of study participant

Study participant mean age of patients in the successful group was 47.6 with an age range from 22 to 26 years, while in the failing group 47.6 with an age range from 9 to 79 years. The distribution of study participants based on gender in the successful group, predominant with male gender (52.3%). Meanwhile, in failing group was predominant with females (57.7%). Patients had diabetes mellitus for more than 5 years in the successful group 38 people

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(48.7%) and in the failed group, 40 people (51.3%). Patients experienced hypertension for more than 5 years in the successful group, namely 58 people (47.2%) and in the failed group, 65 people (52.8%). Almost all patients had never experienced coronary artery disease, occlusive peripheral artery disease and stroke, in the successful group only 1 person (33.3%) had coronary artery disease, 2 people (66.7%) had occlusive peripheral artery disease and 3 people (37.5%) who had a stroke. In contrast, in the failure group only 2 people (66.7%) had coronary heart disease, 1 person (33.3%) had occlusive peripheral artery disease and 5 people (62.5%) had previous stroke. Both group predominant with normal artery. There were differences in local venous conditions in the two groups, in the successful group, person with normal vein was people (76.0%). Meanwhile, only 24% person had normal vein in the failing group. The mean arterial diameter in the successful group was 1.9 mm with a diameter ranging from 1.1 to 3.5 mm, while in the failed group it was 1.7 mm with a diameter ranging from 0.8 to 4 mm. The mean venous diameter in the successful group was 1.5 mm with a diameter ranging from 0.6 to 4.5 mm while in the failed group it was 1.3 mm with a diameter ranging from 0.4 to 4 mm (Table 1).

Table 1 **Characteristics of the study**

Variable	Successful AV-shunt n = 86	Failed AV-Shunt n = 92
Age (years) (mean – min-max)	47.6 (22 – 26)	47.7 (9 – 79)
Sex (n,%)		
Male	56 (52.3)	51 (47.7)
Female	30 (42.3)	41 (57.7)
Diabetes mellitus (n,%)		
Yes	38 (48.7)	40 (51.3)
No	48 (48.0)	52 (52.0)
Hypertension (n,%)		
Yes	58 (47.2)	65 (52.8)
No	28 (50.9)	27 (49.1)
Coronary artery disease (n,%)		
Yes	1 (33.3)	2 (66.7)
No	85 (48.6)	90 (51.4)
Peripheral artery disease (n,%)		
Yes	2 (66.7)	1 (33.3)
No	84 (48.0)	91 (52.0)
Stroke (n,%)		
Yes	3 (37.5)	5 (62.5)
No	83 (48.8)	87 (51.2)
Artery (n,%)		
Normal	71 (60.2)	47 (39.8)
HD puncture	9 (47.4)	10 (52.6)
Stiff, weak pulse	6 (14.6)	35 (85.4)
Vein (n,%)		
Normal	57 (76.0)	18 (24.0)
Puncture HD/blood sample	8 (50.0)	8 (50.0)
Intravenous line	21 (24.1)	66 (75.9)
Artery diameter (mm) (mean – min-max)	1.9 (1.1 – 3.5)	1.7 (0.8 – 4)
Vein diameter (mm) (mean – min-max)	1.5 (0.6 – 4.5)	1.3 (0.4 – 4)

Logistic regression scoring model

A statistical test was performed using logistic regression analysis, it was found that significant variables were local arterial conditions $p = 0.00$ ($p < 0.1$), local venous conditions $p = 0.00$ ($p<0.1$), arterial diameter $p = 0.012$ ($p<0.1$) and vein diameter $p = 0.027$ ($p < 0.1$) for failure of AV-fistula procedure. These three variables will be used in the scoring system for the risk of failure of the artery-venous fistula procedure for access hemodialysis.

Scoring system

The scoring of this variable shows that people with normal veins have a score of 0, a history of veins using access hemodialysis or blood sampling with a scoring of 1, and a vein with a history of intravenous catheters with a score of 2. Artery diameter less than or equal to 1.8 mm will be scored. 1, while arterial diameters of more than 1.8 get a score of 0. Then arteries with a history of puncture hemodialysis will get a score of 1, arteries with a stiff touch and weak pulses get a score of 2, and normal arteries get a score of 0 (Table 3).

Suitability between of the system and the number of patient data that succeed and fail. If the score found is 0 or 1 in the low-risk category, it means that more successful arteriovenous fistulas are expected. If the score obtained is 2 or 3 categorized as moderate risk, which means it is estimated that the success and failure of the arteriovenous fistula are balanced. If the score obtained is 4 or 5 in the category of severe risk, which means that it is estimated that there will be more failed arteriovenous fistulas, seen from the number of data the failure group is more than the successful group (Table 4). So it can be concluded that the scoring categories are 0-1 low risk, 2-3 moderate risk, and 4-5 high risk (Table 5).

Table 2 Logistic regression model

Variable	B	p-value	R^2	OR (CI 95%)
Age	0.001	0.947	0.00	1.00 (0.97 – 1.03)
Female gender	0.406	0.188	0.01	1.50 (0.82 – 2.74)
Diabetes mellitus	-.029	0.924	0.00	0.97 (0.54 – 1.76)
Hypertension	0.150	0.643	0.00	1.16 (0.62 – 2.20)
Coronary artery disease	0.636	0.606	0.00	1.89 (0.17 – 21.21)
Peripheral artery disease	-.773	0.531	0.00	0.46 (0.04 – 5.18)
Stroke	0.464	0.534	0.00	1.59 (0.37 – 6.86)
Artery		0.00*	0.191	
Normal				
HD puncture	0.518	0.30		1.68 (0.63 – 4.44)
Stiff, weak pulse	2.176	0.00		8.81 (3.4 – 22.5)
Vein		0.00*	0.301	
Normal				
Puncture HD/blood sample	1.153	0.043		3.17 (1.04 – 9.65)
Intravenous line	2.298	0.00		9.96 (4.83 – 20.5)
Artery diameter (mm) (mean – min-max)	-.721	0.012*	0.05	0.49 (0.28 – 0.86)
Vein diameter (mm) (mean – min-max)	-.583	0.027	0.04	0.56 (0.33 – 0.94)

*Significant (p<0,1)

Table 3 The proposed scoring system (PAVAS score)

Variable	p-value	Predicted Probability	OR (CI 95%)	Predicted Probability × OR	Scoring
Vein	<0.0001				
Normal	-	0.24			0
Puncture HD/blood sample	0.161	0.50	2.78 (0.67 – 11.56)	1.39	1
Intravenous line	<0.0001	0.76	6.74 (2.98 – 15.23)	5.12	2
Diameter Arteri					
≤ 1.8 mm	0.056	0.60	1.98 (0.98 – 3.98)	1.19	1
> 1.8 mm		0.41			0
Artery	0.084				
Normal	-	0.40			0
HD puncture	0.940	0.53	0.95 (0.27 – 3.35)	0.50	1
Stiff, weak pulse	0.035	0.85	3.15 (1.08 – 9.14)	2.68	2

DISCUSSION

Vascular access is said to be ideal if it can be used for a long time as blood circulation access with minimal complications. An arteriovenous fistula is the most ideal access of all available access to hemodialysis. If the arteriovenous fistula is successful, then it can be used for a long time with low thrombosis and infection rates, less intervention and low cost.[9] It is necessary to evaluate the patient to determine the placement of the vascular access.[2]

Research by Masengu et al.[19] On clinical predictors of functional patency in arteriovenous fistula procedures found that the sex was female (OR: 2.03; 95% CI: 1.37-3.02; p <0.001), lower arm AV-fistula (radiochepalic) (OR: 4.07; 95% CI 2.77-5.92; p <0.001) was associated with failure of patency within 72 hours post-treatment.

Another study by Haidermota et al.[20] which examined patency in AV-fistulas suggested a different scoring system called DISTAL [Diabetes (1 score), ischemic heart disease (1 score), second contralateral procedure (1 score), age> 70 (score 1), and vein diameter <2.0 mm (score 1)] as predictors of AV fistula patency. This scoring has a maximum value of 6, where the two-year patency of the score

Table 4 Scoring system trial

		AV-shunt		
		Successful	Failed	Total
Score	0	28** (32.6%)	10 (10.9%)	38 21.3%
	1	30** 34.9%	7 (7.6%)	37 20.8%
	2	11* (12.8%)	12* 13.0%	23 12.9%
	3	12 (14.0%)	27* (29.3%)	39 21.9%
	4	3 (3.5%)	13* (14.1%)	16 9.0%
	5	2 (2.3%)	23** (25.0%)	25 14.0%
Total		86 100.0%	92 100.0%	178 100.0%

Table 5 Risk skor category terhadap kegagalan dari AV-shunt procedure

Score	Risk
0 – 1	Low risk
2 – 3	Moderate risk
4 – 5	High risk

0 is 85%, then the score 1 is 62%, the score 2 is 44%, the score 3 is 39%, the score 4 is 20%, and the score 5 and 6 which is 0%. The different variations in the scoring factors in this study are thought to be due to differences in individual characteristics.

Another study by Bosanquet et al.[21] that performed a predictor scoring of the patency of radiocephalic AV-fistula suggested a way of scoring CAVeA2T2. This score focused on the ipsilateral central venous access variable, age> 73 years, venous anastomosis <2.2 mm, and previous history of angioplasty, and absence of intraoperative thrill (score 1 for the first three variables, and score two for the next two variables). In this scoring, a score of 0-1 has a 1-year patency of 61%, a score of 2 has a patency of 44%, and a score of more than 3 has a patency of 35%.

All risk factors are evaluated and tested, from these risk factors, there were 3 risk factors that were statistically significant at the radiocephalic location, namely local arterial conditions, local venous conditions and arterial diameter.

CONCLUSION

The use of scoring based on parameters of arterial diameter, local venous condition, and local arterial condition becomes a scoring system for predictors of the risk of failure of the AV-shunt procedure, with three scoring categories, namely low risk (score 0-1), moderate risk (score 2-3), and high risk (score 4-5). This study is preliminary in making arteriovenous fistula scoring (PAVAS Score) because the sample is limited only from East Java and studied only at 1 center hospital. Future research with larger sample size is important to conduct to verify whether the PAVAS score applies to the people of East Java by applying it to patients then testing the sensitivity and specificity.

ETHICAL CONSIDERATION

This study has been approved by Ethical Committee Dr. Soetomo General Hospital with ethical clearance reference number: 156/Panke.KKE/II/2015. All study protocol according to the declaration of Helsinki.

CONFLICT OF INTEREST

All author declares there is no competing interest regarding publication of current study.

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