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Diagnostic validity of CAVeA$_2$T$_2$ score in predicting failure of radiocephalic arteriovenal fistula in terminal stage renal failure patients at Sanglah Hospital, Bali, Indonesia

Ardi Juanda,[1*] Ketut Putu Yasa,[2] I Gede Raka Widiana[3]

ABSTRACT

Introduction: Chronic kidney disease (CKD) is a global public health problem with increasing prevalence and incidence and poor prognosis. As a result, more patients will be in terminal stage kidney failure and require placement of vascular access for hemodialysis. Mature and functional arteriovenous fistula (AVF) is considered the best modality for access to hemodialysis. This study aims to examine the CAVeA2T2 scores in predicting failure of arteriovenous fistula radiocephalic, significant factors related to failure of arteriovenous fistula so that it can be used to predict failure using a scoring system to predict primary failure and secondary failure fistula.

Methods: A cross-sectional study was carried out at Sanglah Hospital, Bali, Indonesia, during the study period. This study using diagnostic test evaluation method using ROC curve analysis on months 1 and 3, a total of 50 populations obtained using Purposive sampling quota period April 2018 - December 2018 and failure of Hemodialysis as gold standard. Data were analyzed using Stata version 12 for Windows.

Results: Results of the CAVeA2T2 score where the maximum score of 7 was analyzed using the ROC curve, the cutoff point was obtained at month 1 ≥5 with AUC 0.8987 and at 3 months ≥ 4 with AUC 0.3966 sensitivity and specificity CAVeA2T2 score of 91.3% and 75% in month 1, in the 3rd month 85.7% and 87.5% were obtained.

Conclusion: Sensitivity and specificity values that provide a good value so that the CAVeA2T2 score can be used to predict failure of arteriovenous radiocephalic fistulas.

Keywords: CAVeA2T2 Score, Arteriovenous Fistula, Fistula Failure

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[1]Surgery Resident, Faculty of Medicine, Universitas Udayana / Sanglah General Hospital, Bali, Indonesia
[2]Cardiothoracic Division, Faculty of Medicine, Universitas Udayana / Sanglah General Hospital, Bali, Indonesia
[3]Internal Medicine, Faculty of Medicine, Universitas Udayana / Sanglah General Hospital, Bali, Indonesia

[*]Correspondence to:
Ardi Juanda; General Surgery Specialist Program, Faculty of Medicine, Universitas Udayana, Sanglah General Hospital, Bali, Indonesia;
ardisinulingga@gmail.com

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INTRODUCTION

The number of patients with end-stage renal disease (ESRD) has increased steadily, a trend that is expected to continue. As a result, more patients will need kidney replacement therapy. Hemodialysis (HD) is a kidney replacement therapy recommended by the Kidney Disease Outcomes Quality Initiative (KDOQI).[1-3] Hemodialysis is a therapy for renal replacement using a dialysis machine. Vascular access is needed to connect blood vessels with dialysis machines.

A mature and functional arteriovenous fistula is considered the best modality for HD access when compared with arteriovenous graft (AVG) and central venous catheter (CVC). It is estimated that about one third (20% - 50%) of the AVF will fail to achieve functional access based on the Rule of 6, which are: blood flow rate> 600 ml/minute, 6 mm vein diameter, <6 mm vein depth, and within 6 weeks.[4,5] At present there are not many scoring systems that are used to predict patency/failure of arteriovenal fistulas. CAVeA2T2 score is one of the scores that can be used to predict AVF patency.[6,7] However, validation tests on CAVeA2T2 scores have never been done.

Based on the aforementioned, this study aims to examine CAVeA$_2$T$_2$ scores in predicting failure of radiocephalic arteriovenous fistula and significant risk factors that are associated with failure of arteriovenous fistula so that they can be used to predict failure in primary and secondary failure fistula.

MATERIAL AND METHODS

This study is an observational study using a cross-sectional evaluation method. The total number of samples was 50 patients in the period April - December 2018 and samples were obtained using consecutive sampling based on inclusion and exclusion criteria. The inclusion criteria were all patients over the age of 18 with terminal stage renal failure undergoing radiosephalic arteriovenal fistula surgery. Exclusion criteria were all patients with incomplete medical records, patients switching to peritoneal dialysis or kidney transplants; there were local infections and complications at the site of the fistula (aneurysm) and physiological disorders of hemostasis.

The CAVeA$_2$T$_2$ score is a risk factor that significantly affects the patency of the radiocephalic

arteriovenous fistula, consisting of ipsilateral CVC access (Score 1), Age > 73 years old (Score 1), Vein diameter < 2.2 mm (Score 1), history of lower limb angioplasty (Score 2), and no peri-operative thrill (Score 2) whereas a maximum score is 7.

Diagnostic tests were used to assess the validity of the $CAVeA_2T_2$ score in predicting arteriovenal fistulas failure in Sanglah General Hospital and looking for the "cut-off" point of the $CAVeA_2T_2$ score. The cut-off point of the CAVeA2T2 score was analyzed using the ROC curve analysis. This data is processed with Stata version 12 for Windows.

RESULT

Based on the characteristic data of the subjects in Table 1, it was found that 26 male subjects (52%), 24 women (48%), 17 people with diabetes mellitus (34%), 33 without diabetes mellitus (66%), suffering from hypertension 35 (70%), not suffering from hypertension 15 (30%), smoking 16 (32%), not smoking 34 (68%), obesity 9 (18%), non-obese 41 (82%). Besides, our study also suggests that the results of failure in month 1 (4 weeks) were 7 (14%) patients and in the third month was found 13 (26%) patients (Table 1).

Table 1 Baseline characteristics of respondents

Variables	Total (N=50)
Sex (n,%)	
Male	26 (52%)
Female	24 (48%)
Diabetes Mellitus (n,%)	
Yes	17 (34%)
No	33 (66%)
Hypertension (n,%)	
Yes	35 (70%)
No	15 (30%)
Smokers (n,%)	
Yes	16 (32%)
No	34 (68%)
Obesity (n,%)	
Yes	9 (18%)
No	41 (82%)
1st-month failure (n,%)	
Fail	7 (14%)
Not fail	44 (86%)
3rd-month failure (n,%)	
Fail	13 (26%)
Not fail	37 (74%)

The results of the diagnostic test using the ROC curve in month 1 (Figure 1) obtained a cut-off point of ≥5 (AUC 0.898; sensitivity of 42.86%, specificity of 97.67%, accuracy of 90%) and at the cut-off value of 3rd month was ≥4 (AUC 0.936; sensitivity of 53.85%, specificity of 97.3%, accuracy of 86%). After obtaining the cut-off point value from the CAVeA2T2 score to predict the occurrence of failure of the arteriovenous fistula on months 1 and 3 a diagnostic test was performed by calculating the 2x2 table (Table 2).

The sensitivity value of the 3rd month $CAVeA_2T_2$ score for predicting the occurrence of AV-Fistula failure at high risk with a cut-off ≥4 of 53.8% (95% CI) (Table 2). The specificity of the $CAVeA_2T_2$ score at month 3 with a cut-off ≥4 to predict the absence of AV-Fistula failure was 97.3% (95% CI). 87.5% NPP value and 85.7% NPN in this study mean good diagnostic value. The value of LR+19.9 in this study gives good results, so the possibility of suffering from the ruling is getting better. And the results of LR- 0.47 in this study give high results (Table 2). In this study, the 1-month accuracy was 90% with a cut-off ≥5 and in the 3rd month it got 86% accuracy with a cut-off point of ≥4.

DISCUSSION

The number of patients with an end-stage renal disease requiring hemodialysis is increasing in the world. Hemodialysis is a therapy for kidney replacement using a dialysis machine.[8,9] Vascular access is needed to connect blood vessels with dialysis machines. The use of access to radiocephalic arteriovenal fistula as access to hemodialysis is recommended because it can be used for an extended period of time, morbidity and mortality are low as access to hemodialysis. In a 2013 study, 20% -50% of arteriovenal fistulas were never used as access to hemodialysis (failed).[2,9-11]

From the data in table 3, as many as 50 patients with terminal stage renal failure requiring radiocephalic arteriovenal fistula as vascular access, 13 (26%) patients failed, and 37 (74%) succeeded in the 3rd month. The results were not much different from a study conducted by Bosanquet's et al. where primary failure was 15.3% and 16.7%.[3,4]

In this study, the average age was 54 years, with an age range of 27-74 years. In a study conducted by Bosanquet et al. (2015) obtained an average age of 72 years. Another study by Martinez et al. received an average age of 64 years.[3,4] This result is consistent with the rate of terminal stage renal failure which occurs at the age of> 50 years.

Based on the size of the cephalic vein diameter was diameter 2.2mm 38 (76%) patients and <2.2mm 12 (24%) patients, in the study conducted

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Table 2 **Diagnostic test results of CAVeA2T2 score in predicting the failure of arteriovenous fistula at 1st and 3rd months.**

Groups	Fail		Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)	Accuracy (95% CI)
1st month	Yes	No							
≥ 5	3	1	42.9	97.7	75	91	18.65	0.58	90
< 5	4	42	(79-970)	(19-99)	(88-100)	(9-81)	(0.6-20)	(0.03-0.3)	(14-86)
3rd month									
≥ 4	7	1	53.8	97.3	87.5	85.7	19.9	0.47	86
< 4	6	36	(71-95)	(47-100)	(85-100)	(25-81)	(1.1-43)	(0.07-0.3)	(26-84)

*PPV: Positive Predictive Value *NPV: Negative Predictive Value
*LR+: Positive Probability Ratio *LR-: Negative Probability Ratio

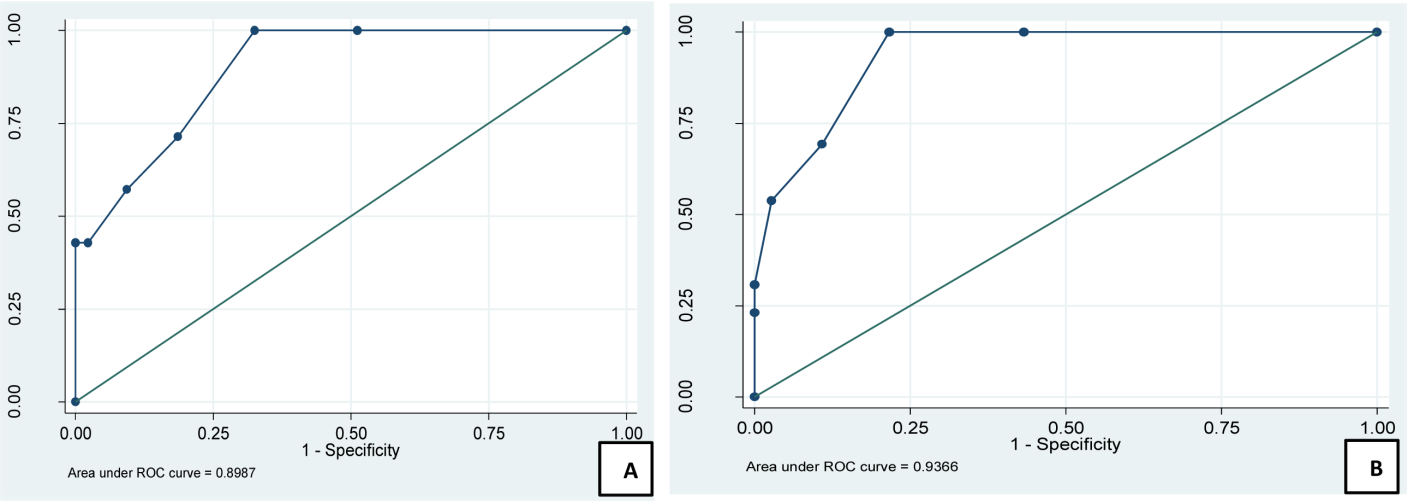

Figure 1 ROC curve $CAVeA_2T_2$ score in predicting failure of radiocephalica arteriovenous fistula in 1st month (A) and 3rd month (B).

by Bosanquet, et al. obtained a diameter size of ≥ 2.2mm (59%) and <2.2mm (41%). The decrease of large vein diameter will cause high shear stress, thereby decreasing hyperplasia neointima.[3-9]

Based on the ipsilateral CVC access distribution obtained 19 (38%) positive patients and 21 (62%) patients were negative, the results obtained were higher than the research conducted by Bosanquet, et al. found 15% of patients were positive and 85% of patients were negative.[3] In a study conducted by Roman, et al. (2012), 15% of patients were positive, and 85% of patients were negative.[7] The ipsilateral radiocephalic arteriovenal fistula with access CVC increases failure due to central venous stenosis which obstructs the blood flow along the outflow tract thereby increasing the occurrence of dilated accessory veins as inhibitors of maturation and increased risk of thrombosis.[3,7]

In this study, the best 3-month "cut-off" point of $CAVeA_2T_2$ ≥4 (AUC 0.9366) was obtained. It can be said that patients with a $CAVeA_2T_2$ ≥4 score (score 4-7) have a high-risk factor for failure of arteriovenous fistula in months 1 and 3, while CAVeA2T2 scores <4 (score 0-3) are a risk factor for low failure of the arteriovenous fistula. The selection of these risk factors is beneficial in the initial identification and stratification of patients. From previous studies, the "cut-off" ≥3 was found to increase the failure of radiocephalic arteriovenous fistula at a score of ≥3 significantly increasing when the longer used as vascular access for hemodialysis, obtained decrease patency (61.5-42.4%) in arteriovenous fistula.[3,11] This situation leads to the cephalic vein diameter less than 2.2 mm can cause a decrease in shear stress causing neointima hyperplasia and access CVC which is known to be a factor in central venous stenosis and obstruction.[11-13] Lower limb PVD / Angioplasty causes thrombus, endothelial inflammation, changes in thickness in the intima-media and decreased blood flow in the arteries. After palpable anastomosis, the presence of thrill confirms that blood flow from the arteries to the vein is inadequate and is a predisposition to the failure of the arteriovenous fistula. The point of "cut-off" is obtained with a score of ≥2 as the risk of failure, which is a failure at week 6 and month 6 (33.3-44.4%).[4,13,14]

The sensitivity value of the 3rd month CAVeA2T2 score to predict the occurrence of

high-risk radiocephalica fistula with a cut-off ≥4 of 53.8% (CI 95%) of this sensitivity value means that the ability of $CAVeA_2T_2$ scores to predict failure of radiocephalica arteriovenous fistulas is 53.8 %. Thus, if 100 patients with a CAVeA2T2 ≥4 score could correctly predict the failure of radiocephalica arteriovenous fistula in 54 patients. This sensitivity value was obtained from 7 patients who failed AV-Fistula with $CAVeA_2T_2$ score ≥4 (true positive) while 6 patients with $CAVeA_2T_2$ score <4 (false negative).

The specificity of the CAVeA2T2 score at the 3rd month with a cut-off ≥4 to predict the failure of radiocephalica arteriovenous fistula was 97.3% (95% CI). Thus if 100 patients with radiocephalica arteriovenous fistula did not fail, the $CAVeA_2T_2$ score correctly predicted no failure in 97 patients. This specificity was obtained from 37 patients with no radiocephalica arteriovenous fistula. Where 36 patients with CAVeA2T2 score <4 (true negative) while 1 patient with CAVeA2T2 ≥4 (false positive). CAVeA2T2 score ≥4 in 1 patient (false negative) that did not fail the arteriovenous fistula because it might be caused by the radial and cephalic vascular arteries and the patient did not have diabetes mellitus.

Percentage of PPV (Positive Predictive Value) 87.5% and NPV (Negative Predictive Value) 85.7% in this study have good diagnostic values. This value implies that it can predict the failure of radiocephalica arteriovenous fistula, the CAVeA2T2 score can correctly predict the failure of radiocephalica arteriovenous fistula by 87.5%, and if the CAVeA2T2 score predicts no failure of 85.7%. This PPV and NPV value strengthens sensitivity and specificity.

The value of LR+ (Likelihood Ratio +) 19.9 in this study gives good results, so the possibility of suffering from ruling in is getting better. And the results of the LR- (Likelihood Ratio-) of 0.47 in this study yield high results, so that it can show the probability of negative test results in patients without radiocephalic arteriovenous fistula from those who failed the CAVeA2T2 score (<4).

Also, accuracy is the ability of a test to detect correctly from all the subjects being tested. In this study, the 1-month accuracy was 90% with a cut-off ≥5 and in the 3rd month it got 86% accuracy with a cut-off point ≥4, which means that CAVeA2T2 score measurement can be said to be accurate.

CONCLUSION

Using vascular access for hemodialysis is the gold standard and recommended by KDOQI, estimated that 1/3 will fail, $CAVeA_2T_2$ ≥4 score is a high-risk factor for failure of radiocephalic arteriovenous fistula in end-stage renal disease patients, selection of renal replacement therapy can be considered using Other access in patients with a score of ≥4 such as double-lumen permanent, peritoneal dialysis, kidney transplantation, and to reduce the failure rate in patients with diabetes mellitus is done by controlling their blood sugar levels.

ETHICAL CLEARANCE

This study has been obtained the ethics approval from the faculty of medicine, Universitas Udayana, Sanglah General Hospital, Bali, Indonesia, with number 1488/UN14.2.2.VII.14/LP/2019

CONFLICT OF INTEREST

The authors declare that there is no competing interest regarding the manuscript.

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