SUBMITTED 28 FEB 2023
REVISIONS REQ. 4 APR 23; REVISIONS RECD. 11 JUL 23
ACCEPTED 18 JUL 23
ONLINE-FIRST: SEPTEMBER 2023
DOI: https://doi.org/10.18295/squmj.9.2023.050

Factors Affecting Early Maturation of Arteriovenous Fistulae Created at a Tertiary Centre in Oman

Sheikha Al Hashmi,[1] Shouq Al Hudar,[1] Edwin Stephen,[2] *Dawood Al Riyami,[3] Hanan Al Maawali,[2] Ibrahim Abdelhady,[2] Khalifa Al Wahaibi,[2] Syed Rizvi[4]

Departments of [2]Surgery and [3]Internal Medicine, Sultan Qaboos University Hospital and [4]Department of Family Medicine & Public Health, [1]Sultan Qaboos University, Muscat Oman.
**Corresponding Author's e-mail*: dawood@squ.edu.om

Abstract

Objectives: An arteriovenous fistula is ideal for vascular access, the maturation of which is vital for hemodialysis. Our aim was to determine the risk factors associated with failure of maturation of arteriovenous fistulae. ***Methods:*** This retrospective cohort study, from January 2014 to December 2018 was conducted in a tertiary care hospital in Oman, Patients were followed up for three months after surgery. Electronic medical records were accessed for demographics and clinical data. Data was analyzed using SPSS package. Univariant analysis was used to determine the risk factors associated with early maturation of AVF and multi variant analysis used to determine the predictive risk factors. ***Results:*** There were a total of 269 patients in the study. Female gender was a significant factor affecting maturity (P= 0.027). While factors not affecting maturation were age (P= 0.320), diabetes (P= 0.858), hypertension (P= 0.215), dyslipidemia (P= 0.215), coronary artery disease (P= 0.433), cerebrovascular accident (P= 0.864), congestive heart failure (P= 0.509), previous central venous catheter creation (P= 0.11), fistula type (P= 0.863) and fistula side (P= 0.861). Binary logistic regression showed that all risk factors were insignificant. Failure of early maturation was 11.5%. ***Conclusion:*** Our research has shown that the early maturation proportion of arteriovenous fistulae created at our hospital is at par with international literature. Failure of maturation was significantly associated with the female gender. Results of this study can help nephrologists

and vascular surgeons prognosticate maturation rates of arteriovenous fistulae. However, a larger study is needed for definitive conclusions.

Keywords: CKD; AVF; maturation; early; failure; Oman.

Advances in knowledge

1- The outcome of this study will provide a guide to the vascular access team concerning proportion of early primary failure and its factors that predict it among Omani patients.

Application to patient care

1- Knowing the associated risk factors will help improve the outcome, increase success rates of patency of AVF's and hence quality of life of end stage renal disease patients in Oman.

Introduction

The incidence of end-stage renal disease (ESRD) in Oman in 2013 was 120 per million population. It was more prevalent in males (57.1%) than females (42.9%). The leading risk factor was diabetic nephropathy (46%), followed by hypertensive nephropathy (19%).[1]

An arteriovenous fistula (AVF) is a surgically crafted anastamosis between an artery and a vein at the level of the wrist, elbow, axilla or groin. This connection increases the blood flow through the vein, enlarges it and over time makes it thicker, allowing the dialysis needles to be inserted and hemodialysis [HD] to be performed. This change that the vein undergoes is called maturation of the fistula when combined with the proportion of blood flow through the vein of at least 300ml/min. This process normally take six weeks from this time the AVF was created. AVF's are the commonest vascular access for HD, but are fraught with a high proportion of failure to mature. [2,3]

Literature defines "failure of maturation" when the fistula does not achieve at least one of these targeted criteria 6 weeks after AVF creation: (1) Blood flow proportion is greater than 600 mL/minute; (2) Vein diameter is less than 6mm; and (3) It has a maximum of 6mm depth from the skin surface.[4]

Multiple factors are involved in the functional maturation of AVFs, these factors can be demographic factors including patient age, sex, race/ethnicity, clinical factors such as presence

of cardiac disease, peripheral arterial disease, pulmonary hypertension, diabetes mellitus, obesity.[5] Hemodynamic factors including vein size, feeding artery size, blood flow and technical factors like training / experience of the surgeon in AVF creation, care and use of the AV fistula. A study done in South Korea, showed that failure of maturation in their cohort of 60 patients was 15%.[6,7]

This study aims to determine the proportion and risk factors associated with early failure of maturation of arteriovenous fistulae created at our tertiary care hospital.

Methods

This is a retrospective cohort study conducted in a tertiary hospital in Muscat, Oman following ethical approval from the medical research ethics committee at the college of medicine and health sciences in Sultan Qaboos University.

The study included all adult Omani patients who underwent AVF creation in the hospital from January 2014 to December 2018 and primary patency assessed at three months. The exclusion criteria included patients who hadn't used the AVF for HD or had succumbed within the 3-month follow-up period.

For the purpose of the study, patients were divided into those below 65 years of age and those 65 and above, based on the WHO definition of "elderly".

Data was collected from the hospital's electronic medical record system and included patient demographics such as age, gender, weight, height; history of previous tunneled neck central venous catheter or failed AVF creation and comorbidities - hypertension (HTN), diabetes (DM), dyslipidaemia (DLP), coronary artery disease (CAD), congestive heart failure (CHF), cerebral vascular accident (CVA). All patients underwent a pre-op ultrasound mapping and a venogram was performed if there was history of a tunnelled catheter. AVF's were created by a group of 3 surgeons. Surgical details collected, included anatomical factors such as type of the fistula- radio-cephalic AVF (RCAVF), brachio-cephalic AVF (BCAVF), brachio-basilic AVF (BBAVF), and site of the fistula (left, right arm).

All patients were on 100 mg of aspirin pre and post operatively. An anticoagulant was used only in patients with atrial fibrillation. Furthermore, information about the HD sessions like

blood flow through the dialyzer and outcomes of arteriovenous fistulas maturation were obtained.

The collected data was recorded as numbers in Statistical Package for Social Sciences (SPSS) program version 23. The fistulae were evaluated at 3 months post creation for success of HD for minimum of 6 sessions with adequate flow rate/s and ease of cannulation. AVF was considered mature based on these criteria. For the continuous variables, mean and standard deviation were used. Body mass index (BMI) was calculated as body weight (Kgs.)/ height(meters)^2, obesity was defined as BMI > 29.9 kg/m^2 and overweight was defined as BMI between 25-29.9 kg/m^2. Chi square test was used to find the association between the proportion of failure of maturation of AVF and the studied variable. A" p" value <0.05 was considered significant. Frequency tables were used to get the frequencies and percentages of demographic variables as well as the prevalence of the disease. Multivariate analysis: Binary logistic regression analysis has also been performed to identify the significant independent factors.

Results

Two hundred and eighty two patients underwent AVF creation during the study period. After excluding patients who did not use the AVF for HD during the three month follow-up and those who died before using the fistula, there was a cohort 269 patients in the study. (Figure 1). Failure of early maturation occurred in 11.5% of patients at 3 months' post creation. There were 161 (59.9%) males and 108 (40.1%) females. The mean age was 54.8 ±15.7 years (Age range: 18-90). BCAVF was the most common type of AVF created (195; 72.5%) followed by BBAVF (64; 23.8%) and RCAVF (10 patients; 3.7%). Further demographic distributions are demonstrated in Table 1.

In the 269 patients, 13 out of 162 males (8%) and 18 out of 107 (16.7%) females had failure to mature at 3 months (P = 0.049) showing a significant association between gender and failure and a Relative Risk of 2.28. Binary logistic regressions analysis also concluded similarly.

Majority of the patients (72.1%) were elderly with an early failure of AVF maturation of 9.3% and in the subset 65 years and below (27.9%) , the failure proportion was 12.4% (P= 0.626).

Obese patients were those with BMI > 29.9 kg/m^2 (27.1%) of the cohort; overweight patients with BMI between 25-29.9 kg/m^2 (45.7%) and the remaining patients (27.1%) had BMI < 25

kg/m^2. The early failure proportion among obese, overweight and normal BMI patients was 13.7%, 11.4% and 9.6% respectively (P= 0.73).

Hypertension was the commonest co-morbidity (242 patients; 89.9%) followed by Diabetes (181 patients; 67.2%); CAD (63 patients; 23.4%) and past history of CVA in 28 patients (10.4%). 26 of the 31 patients with failed AVF were hypertensive (P= 0.215). Diabetic patients constituted 179 (66.5%) of the cohort, 11.7% of them had a early failed AVF compared to the non-diabetic patients (11.2%) (P= 0.858). Sixty-three patients (23.4%) in our study had CAD; 9 of them (29.0%) had early failure of AVF (P=0.433). (10.4%) had a history of CVA; 4 of them who have failed AVF (P= 0.864).

Out of the 31 patients with failed AVF, 26 had hypertension (10.7% ; P= 0.378); 21 had DM (11.7% : P= 0.954); 9 had CAD (14.3% : P= 0.576) : 4 had history of CVA (14.3% : P =0.864);11 of them had a previous history of DLP (P=0.907) : 4 of them with a history of CHF (P=0.685) and 26 patients (83.9%) had a previous CVC insertion (P=0.05).

The rate of failure of maturation in each type of fistula is as follows, RCAVF 1 (10%), BCAVF 21 (10.7%), BBAVF 9 (14%) (P =0.863).

In the 269 AVF's created, 220 were created in the left upper limb and 49 in the right. Twenty-five (11.4%) of the left sided fistulas have failed to mature compared to 6 (12.2%) failed fistulas in the right side (P=0.861).

Univariate analysis showed only gender as the significant risk factor to failure to mature, females were found to have 2.277 times risk of failure to mature as compared to males. For performing the binary logistic regression analysis BMI and HTN were also added as the risk factors and the outcome of the analysis showed all the three risk factors as insignificant (Table 3).

The rate of early failure of AVF maturation was 11.5%. That means, 31 newly created AVF considered primary failed AVF because it never develops adequately to support the dialysis or fails to be needled within the first three months of its creation or impossibility to achieve more than 300 mL/min that needed for successful dialysis treatment.

Discussion

This study was the first of its kind in the Sultanate of Oman as found in English literature. It was done to find the prevalence of failure of early maturation of AVF in Omani adults and the associated risk factors related to this key performance indicator (KPI).

This paper shows that the rate of maturation of AVF created at a single centre in Oman determined at 3 months post creation was 88.5%. This study shows a lower proportion of early AVF failure when compared with other single centre international studies from North America, Korea and Netherlands.[6,7,8] Previous studies used ultrasound to evaluate artery size, venous dimensions, blood flow and subsequently predicted the AVF maturation.

This study depends on another definition for early failure AVF maturation. Non matured AVF is the AVF that fails to be cannulated during the dialysis sessions or fails to achieve blood flow ≥300 mL/min within 3 months of its creation. The reason behind the difference in the early failure proportion of AVF between this study and previous research could be due to the relative lower mean age of our cohort, higher proportion of BCAVF, variability of the definition that was used to define failed AVF. Added to this is difference in number of centres involved, surgeons experience, conduction of primary assisted/ secondary interventions and ethnicity that affect the results. The higher proportion of BCAVF in our cohort reflects the effect of the pre-opertative vein mapping which led to appropriate avoidance of RCAVF which is known to have higher proportion of failure. Hence, sparing the patient from undergoing a second surgery.

There is no significant difference in the early failure proportion of AVF between age groups. This result is inconsistent with the meta-analysis conducted in the USA. It revealed a statistically significantly higher proportion of failure to mature of AVF in elderly patients compared with an odds ratio (OR) of 1.525. This significant difference is explained by the presence of comorbidities like diabetes, DLP and cardiovascular disease in elderly patients that show a stronger effect on AVF maturation, rather than age alone. Furthermore, elderly patients exhibit problems including arteriosclerosis, poor-quality veins and thin skin that affect the maturation process of the vascular access.[9] The explanation for this conflict can be because of relative significant lower mean of the age of our cohort. The disparity can also be due to the exclusion of older patients who die before using AVF from the statistical analysis.

The study shows a significant difference in outcomes of early failure AVF maturation between males and females. Female patients have a higher failure proportion of AVF compared to male patients. This finding is consistent with a cohort study done in the USA. It found that fistula adequacy for dialysis was lower in females compared to males (31 vs. 51%). In fact, increasing blood flow through the arteriovenous connection and adequate dilation of the blood vessel are essential variables required for AVF maturation.[10] This significant difference in failure proportion explained by smaller vessels of the female patients compared to males, so decrease the chance for the new fistula to mature to adequate size. Another possible explanation between male and female includes differences in vascular reactivity and platelet aggregation after vascular injury. In addition to the difference in the ability of the veins to be dilated when exposed to high pressure between genders as a result of AVF creation.[11]

Our study shows no significant difference in the early failure proportion of AVF between obese, overweight and normal BMI patients. This finding is inconsistent with a cohort study done in the USA, which found that obese patients had a higher failure proportion compared to non-obese patients with a relative risk (RR0 of 3.05. In fact, obese patients have higher levels of C-reactive protein, which induce blood vessel intimal hyperplasia resulting in stenosis and thrombosis. Obese patients also have a hypercoagulable state which increases the likelihood of thrombus formation and subsequently, reduces the chance of AVF to be mature and usable. A second potential explanation is that obesity makes it difficult for the surgeon to identify suitable vessels for fistula creation. In addition, obese patients could have very deep arteriovenous connections that can't successfully be cannulated by the dialysis needle. As a result, the fistula must undergo transposition to be sufficiently superficial to offer anatomic landmarks and safe cannulation.[12,13] The difference in findings with the previous studies perhaps can be explained by the small sample size and the relatively lower mean of BMI in our cohort.

Our research indicated that there is no relation between hypertension and failure of AVF maturation. This result is supported by studies done by Kim et al, and another one conducted in USA.[14,15]

Diabetes mellitus has been considered as a significant predictor of AVF failure of maturation in a study conducted in San Francisco (USA). It is explained by the fact that DM causes metabolic changes that can cause endothelial changes and growth factors deregulation with increased matrix deposition, all of these may lead to stenosis and thrombosis and thus failure

of maturation of AVF.[16] Our study has shown that DM is not a significant risk factor for AVF failure of maturation in agreement with a study was done by the University of Arizona Health Sciences Center in Tucson (USA).[15]

Dyslipidemia has been considered as a non-significant factor affecting the AVF maturation. The result conflict with a study was published in Canada that has indicated the DLP as a significant risk factor explaining that by the role of dyslipidemia in forming calcified plaques, leading to subintimal hyperplasia and decreasing the vessels diameter and that cause the failure of maturation of AVF. The interference between the results can be due to the sample size and the fact that the DLP percentage between the group with failure and those with non-failure is very close; that is not making differences between each.

Coronary artery disease is considered as one of the main causes leading to atherothrombosis. Which in sequence can cause thrombosis of connected vessels of AVF and thus failure of AVF maturation.[17] A prospective study was done on 422 patients has shown that CAD is a significant factor affecting the failure of AVF maturation. This result conflict with ours, which has indicated that CAD is not significant in determining the failure of AVF maturation. The conflict between the two results can be explained by the difference in the sample size between the two studies and the difference in the type of study itself.[18]

Cerebrovascular accident was considered as a non-significant factor in our study, which coincided with the results of a study that was done in Canada.[18] The agreement between the results strongly indicates that there is no relation between CVA and failure of AV maturation.

Our results have shown that congestive heart failure is not a significant factor affecting the AVF failure. The result is supported by three other studies which have been done in Portugal, Canada and USA, respectively.[18,19,20]

There was a discrepancy between studies about the relation of previous central venous catheter creation with the failure of maturation of AVF. A study was done in USA has shown that Pre-CVC is a significant risk factor that may affect the AVF maturation, explaining that by the effect of Pre-CVC in forming stenosis thus affecting the vascular access outcomes.[15] Our result has shown that Pre-CVC is not a significant risk factor in this case which coincided with the results of a study that was done in Tuscon (USA) from 2003-2007 among 298 patients.[20]

Lauvao et al has shown that there is no relation between type/site of AVF (RCAVF, BCAVF, BBAVF) with its maturation, and that agrees with our research results.[21] However, this result can be referred to the fact that AVF maturation depends more on the diameter of the vessels used and how healthy are they.

It is preferred that the arteriovenous fistula be created on the non-dominant arm or the arm that not used frequently. As a result, the patients will have a free dominant hand, allowing the patient to complete the desired activities more easily during the dialysis session. However, if the non-dominant arm is not suitable for AVF creation, the dominant arm will be used.[22] This study shows no significant variation in failure proportion of AVF whether the AVF is created in the right or left arm of the patients. This finding is consistent with a single-centre cohort study done in the United Kingdom (UK), which found no significant difference in failure proportion of fistulas between dominant and non-dominant arms.[23]

One of limitations of our study is its retrospective nature which can affect the results due to lack of some data in the patients record. Secondly, it is a single-centre study, and although SQUH is a large referral centre, it would not represent the results in other centres in Oman. Third is that our cohort is small and duration of follow-up short.

Conclusion

The proportion of early failure of AVF maturation was 11.5% which is in the lower range of reported international literature. We found that the female group of patients had a higher risk for failure of AVF maturation. Preoperative ultrasound guided mapping is helpful to evaluate and choose the appropriate vessel for AVF creation and for postoperative follow up of the fistula to check AVF maturity or detect early complications. This group of patients should be closely monitored as endovascular or surgical intervention can be offered to improve primary patency of a fistula.

Authors' Contribution

DR conceptualized and designed the study. ES and KW contributed to methodology design. SHa, SHu and HM collected the data under supervision of DR. All authors drafted the manuscript and approved the final version of the manuscript.

Conflict of interest

The authors declare no conflict of interests.

Funding

This research did not receive any funding.

References

1. Al Alawi I, Al Salmi I, Al Mawali A, Al Maimani Y, Sayer J. End-Stage Kidney Failure in Oman: An Analysis of Registry Data with an Emphasis on Congenital and Inherited Renal Diseases. Kidney Int Rep 2017; 2017:1-7. https://doi.org/10.1155/2017/6403985.
2. Ethier J, Mendelssohn D, Elder S, Hasegawa T, Akizawa T, Akiba T et al. Vascular access use and outcomes: an international perspective from the dialysis outcomes and practice patterns study. Nephrology Dialysis Transplantation. 2008; 10:3219-3226. https://doi.org/10.1093/ndt/gfn261.
3. Malovrh M. Non-matured arteriovenous fistulae for haemodialysis: diagnosis, endovascular and surgical treatment. Bosn J Basic Med Sci 2010; 1:13. https://doi.org/10.17305/bjbms.2010.2640.
4. Siddiqui M, Ashraff S, Carline T. Maturation of arteriovenous fistula: Analysis of key factors. Kidney Res Clin Pract 2017; 4:318-328. https://doi.org/10.23876/j.krcp.2017.36.4.318.
5. MacRae J, Oliver M, Clark E, Dipchand C, Hiremath S, Kappel J et al. Arteriovenous Vascular Access Selection and Evaluation. Can J Kidney Health Dis 2016; 3:205435811666912. https://doi.org/10.1177/2054358116669125.
6. Choi S, Park M, Kim J, Hwang S, Her K, Won Y. Impact of initial blood flow on outcomes of vascular access in hemodialysis patients. Kidney Res Clin Pract 2012; 3:151-156. https://doi.org/10.1016/j.krcp.2012.06.008.
7. Hentschel D. Determinants of Arteriovenous Fistula Maturation. Clin J Am Soc Nephrol 2018; 9:1307-1308. https://doi.org/10.2215/CJN.08860718.
8. Voorzaat B, van der Bogt K, Janmaat C, van Schaik J, Dekker F, Rotmans J. Arteriovenous Fistula Maturation Failure in a Large Cohort of Hemodialysis Patients in the Netherlands. World J Surg 2017; 6:1895-1903. https://doi.org/10.1007/s00268-017-4382-z.

9. Kim S, Min S, Ahn S, Min S, Ha J. Outcomes of Arteriovenous Fistula for Hemodialysis in Pediatric and Adolescent Patients. Vasc Specialist Int 2016; 3:113-118. https://doi.org/10.5758/vsi.2016.32.3.113.
10. Schinstock C, Albright R, Williams A, Dillon J, Bergstralh E, Jenson B et al. Outcomes of Arteriovenous Fistula Creation after the Fistula First Initiative. Clin J Am Soc Nephrol 2011; 8:1996-2002. https://doi.org/10.2215/CJN.11251210.
11. Lazarides M, Georgiadis G, Antoniou G, Staramos D. A meta-analysis of dialysis access outcome in elderly patients. J Vasc Surg 2007; 2:420-426. https://doi.org/10.1016/j.jvs.2006.10.035.
12. Miller C, Robbin M, Allon M. Gender differences in outcomes of arteriovenous fistulas in hemodialysis patients. Kidney International 2003; 1:346-352. https://doi.org/10.1046/j.1523-1755.2003.00740.x.
13. Kats M, Hawxby A, Barker J, Allon M. Impact of obesity on arteriovenous fistula outcomes in dialysis patients. Kidney International 2007; 1:39-43. https://doi.org/10.1038/sj.ki.5001904.
14. Kim J, Jeong J, Song Y, Kim H, Lee W, Kim K et al. Obesity-related decrease in intraoperative blood flow is associated with maturation failure of radiocephalic arteriovenous fistula. J Vasc Surg 2015; 4:1010-1017. https://doi.org/10.1016/j.jvs.2015.05.008.
15. Kim J, Chang W, Oh T, Jeong Y. Venous Distensibility as a Key Factor in the Success of Arteriovenous Fistulas at the Wrist. Ann Vasc Surg 2011; 8:1094-1098. https://doi.org/10.1016/j.avsg.2011.05.014.
16. Lauvao L, Ihnat D, Goshima K, Chavez L, Gruessner A, Mills J. Vein diameter is the major predictor of fistula maturation. J Vasc Surg 2009; 6:1499-1504. https://doi.org/10.1016/j.jvs.2009.02.018.
17. Conte M, Nugent H, Gaccione P, Roy-Chaudhury P, Lawson J. Influence of diabetes and perivascular allogeneic endothelial cell implants on arteriovenous fistula remodeling. J Vasc Surg 2011; 5:1383-1389. https://doi.org/10.1016/j.jvs.2011.05.005.
18. Chen S, Chang J, Hwang S, Tsai J, Wang C, Mai H et al. Significant Correlation between Ankle-Brachial Index and Vascular Access Failure in Hemodialysis Patients. Clin J Am Soc Nephrol 2009; 1:128-134. https://doi.org/10.2215/CJN.03080608.
19. Lok C, Allon M, Moist L, Oliver M, Shah H, Zimmerman D. Risk Equation Determining Unsuccessful Cannulation Events and Failure to Maturation in

Arteriovenous Fistulas (REDUCE FTM I). Clin J Am Soc Nephrol 2006; 11:3204-3212. https://doi.org/10.1681/ASN.2006030190.

20. Wong V, Ward R, Taylor J, Selvakumar S, How T, Bakran A. Factors associated with early failure of arteriovenous fistulae for haemodialysis access. EJVES Vasc Forum 1996; 2:207-213. https://doi.org/10.1016/s1078-5884(96)80108-0.
21. Schinstock C, Albright R, Williams A, Dillon J, Bergstralh E, Jenson B et al. Outcomes of Arteriovenous Fistula Creation after the Fistula First Initiative. Clin J Am Soc Nephrol 2011; 8:1996-2002. https://doi.org/10.2215/CJN.11251210.
22. Lauvao L, Ihnat D, Goshima K, Chavez L, Gruessner A, Mills J. Vein diameter is the major predictor of fistula maturation. J Vasc Surg 2009; 6:1499-1504. https://doi.org/10.1016/j.jvs.2009.02.018.
23. Field M, Khawaja A, Ellis J, Nieto T, Hodson J, Inston N. The vascular access questionnaire: a single centre UK experience. BMC Nephrology 2019; 1. https://doi.org/10.1186/s12882-019-1493-9.

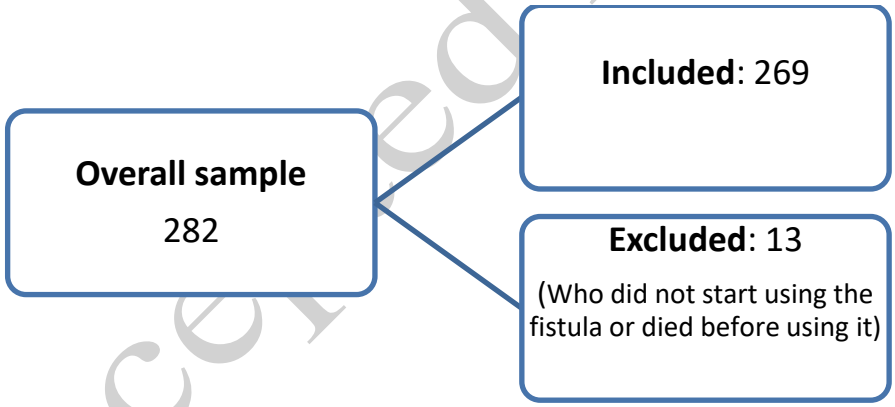

Figure 1: Sample recruitment flow

388 Table 1: Distribution of the study participants among different variabilities

Characteristics		**Value (%)**
Age	Mean ± SD Min max	54.8 ± 15.7 18 90
Gender	Male	161 (59.9%)
	Female	108 (40.1%)
Body mass index	Mean ± SD Minimum Maximum	28.0 ± 6.3 13.9 54.9
Side of AVF	Right	49 (18.2%)
	Left	220 (81.8%)
Type of AVF	Radio-cephalic	10 (3.7%)
	Brachiocephalic	195 (72.5%)
	Transposed Brachio-basilic	64 (23.8%)
Comorbidities	HTN	242 (89.9%)
	DM	181 (67.2%)
	Dyslipidemia	99 (36.8%)
	CAD	63 (23.4%)
	CHF	46 (17.1%)
	CVA	28 (10.4%)
	PVD	13 (4.8%)

389 *Standard deviation (SD), arteriovenous fistula (AVF), hypertension (HTN), diabetes (DM), dyslipidaemia (DLP), coronary*
390 *artery disease (CAD), congestive heart failure (CHF), cerebral vascular accident (CVA)*

391 Table 2: Analysis of risk factors associated with failure of AVF maturation

Characteristic	Total	n (%)		p-value
		Failed AVF (n = 31)	Mature AVF (n = 238)	
Gender				
Male	**161**	**13 (8.1)**	**148 (91.9)**	**P= 0.049**
Female	**108**	**18 (16.7)**	**89 (83.3)**	**RR= 2.277**
BMI				
Normal BMI	73	7 (9.6)	66 (90.4)	P= 0.737
Overweight	123	14 (11.4)	109 (88.6)	
Obese	73	10 (13.7)	63 (86.3)	
Age				
< 65	194	24 (12.4)	170 (87.6)	P= 0.626
≥ 65	75	7 (9.3)	68 (90.7)	
Previous catheter				
Yes	249	26 (10.4)	223 (89.5)	P= 0.05
no	20	5 (25.0)	15 (75.0)	
Anatomical site				
RCAVF	10	1 (10.0)	9 (90.0)	P=0.863
BCAVF	195	21 (10.7)	174 (89.3)	
BBAVF	64	9 (14.0)	55 (86.0)	
Side of AVF				
Left	220	25 (11.4)	195 (88.6)	P=0.861
Right	49	6 (12.2)	43 (87.8)	
Hypertension				
Yes	242	26 (10.7)	216 (89.3)	P= 0.378
No	27	5 (18.5)	22 (81.5)	
Diabetes Mellitus				
Yes	181	21 (11.7)	159 (88.3)	P= 0.954
No	88	10 (11.2)	79 (88.8)	
Dyslipidaemia				
Yes	98	11 (11.2)	87 (88.8)	P= 0.907
No	171	20 (11.7)	151 (88.3)	
CAD				
Yes	63	9 (14.3)	54 (85.7)	P = 0.576
No	206	22 (10.7)	184 (89.3)	
CHF				
Yes	46	4 (8.7)	42 (91.3)	P= 0.685
No	223	27 (12.1)	196 (87.9)	
CVA				
Yes	28	4 (14.3)	24 (85.7)	P= 0.864
No	241	27 (11.2)	214 (88.8)	

392 *Number (n), percentage (%), AVF: arteriovenous fistula, body mass index (BMI) ,P value (P), Radio cephalic AVF (RVAVF),*
393 *brachio cephalic AVF (BCAVF), Brachio basilic AVF (BBAVF), coronary artery disease (CAD), congestive heart failure (CHF),*
394 *cerebellar vascular accident (CVA).*

395

396 Table 3: Risk and 95% Confidence interval using univariate and multivariate (logistic
397 regression) analysis

Characteristic	Univariate		Multivariate	
	Risk	**95% CI**	**Risk**	**95% CI**
Gender	2.277	1.065 - 4.869	1.860	.782 – 4.425
Hypertension	0.530	0.158 – 1.518	0.606	.153 – 2.409
BMI	1.544	0.650 – 3.668	1.526	.604 – 3.854

398