ORIGINAL ARTICLE

Predictive Factors For A Successful Arterio-Venous Access For Haemodialysis.

Neemesh Manohar Lodh,
Department of Surgery, BKL Walawalkar Rural Medical College and Hospital, Sawarde, Tal:Chiplun, Dist:Ratnagiri Maharashtra, India.

Abstract:

Background: This study, aimed to model associations between multiple predictor variables and arteriovenous fistula (AVF) maturation,is based on post-surgery data from 80 patients that received an AVF construction for the first time by a single surgeon. Using these data the factors associated with successful AVF that may have an important role in improving AVF patency rates are elucidated.**Methods:** This prospective study included 80 patients undergoing an AVF construction for the first time by a single surgeon, & followed them up till ascertainment of successful AVF maturation. Multivariable logistic regression methods were used to model associations between multiple predictor variables and AVF maturation. We constructed receiver operating characteristic (ROC) curves, by plotting sensitivity versus specificity of our model predicting AVF maturation. We used the area under the ROC curve (AUC) and odds ratio for predicting optimum venous & arterial diameters for AVF construction. **Results:** With an overall AVF patency rate of 60 %, the highest patency rates were observed in brachiobasilic AVFs (89.50%), while brachiocephalic & radiocephalic AVFs had patency rates of 47.10% & 55.60% respectively. Distal venous diameter (ROC cut off) > 2.2mm was a significant predictor of a successful AVF. Using odds ratio, a vein having a diameter of ≥ 2.2mm was 4 times more likely to yield a patent fistula. Proximal arterial diameter (ROC cut off) > 3mm was a significant predictor of a successful AVF. Using odds ratio, an artery having a diameter of ≥ 3 mm was 3 times more likely to yield a patent fistula. Previous central venous catheterization, brachial artery diameter, proximal cephalic vein diameter and distal basilic vein flow velocity are significant predictors of a working AVF as the final outcome. The type of AVF constructed carries no significance as far as prediction of a working AVF is concerned. The age, sex, End Stage Renal Failure (ESRF), Hypertension, Diabetes Mellitus & duration of disease had no significance in predicting a successful AVF.

Conclusion:
As per our study, the chances of a working AVF were higher in patients with no previous central venous catheterization, a distal venous diameter of ≥ 2.2mm and a proximal arterial diameter of ≥3mm.

Key Words:
Arteriovenous fistula (AVF), Haemodialysis (HD), Receiver Operating Characteristics curve (ROC).

Introduction:

With a population over a billion, and an exponential rise in the cases of diabetes, India

is fast becoming the leading nation of patients with (ESRF). Approximately 1 million new cases are detected each year, out of which 90 % never see a nephrologist. Of the 10 % who do see a nephrologist, Renal Replacement Therapy (RRT) in the form of haemodialysis, peritoneal dialysis or renal transplantation is initiated in 90 % patients. The remaining 10% are simply unable to afford the prohibitive cost of therapy. [1] HD is an integral part of RRT, and constitutes a short- term measure to cover the run-up to renal transplantation without overt uremic symptomatology. [2] In such a scenario, it is even more pertinent to have a working AVfistula. A study of the various factors which could have a predictive role in the successful maturation and patency of an AV fistula was hence undertaken.

Material & Methods:
Subjects & Data:

We conducted a prospective study of predictive factors for a successful AVF maturation. In all 80 patients were chosen for the study as per the inclusion and exclusion criteria laid down prior to the study. The study was a prospective one for a period of 2 years, from February 2007 to February 2009 and included male and female patients of all ages with ESRF, planned for an AVF for the first time. The study was commenced after due approval from the hospital ethics committee. Patients with a prior history of fistula surgery, those with vessels unsuitable for a primary AVF, those with arm oedema, especially with a history of prolonged central venous catheterisation & those who were candidates for primary AV graft procedures were excluded from this study. All AVFs were constructed by the same surgeon, under uniform operating conditions.
Only the first surgical AVF construction during the follow- up period was considered for each study subject. Study variables, including such demographics as age, race, and sex and the presence of various comorbid conditions, such as hypertension and diabetes, were recorded from available medical records. Additionally, cause and length of ESRF and time on dialysis therapy before the surgery were ascertained for each subject.

Preoperative AV mapping was carried out in all patients to assess the most suitable vessels for AVF construction.
AV mapping:
The Colour Doppler imaging was carried out using a Philips Envisor machine with a linear phased array dual high frequency probe of 3-12 Megahertz.

Method: The patient was seated with the arm uncovered & outstretched on a pillow.

The veins were mapped along their natural course, at three places; namely the cephalic vein at the wrist & the cubital fossa, & the basilic vein along the medial aspect of the arm upto the subclavian vein, to see for the patency of the proximal central veins. The depth, diameter of the vessels & the flow across the veins was recorded.

Veins which were thin walled, varied in size with respiration, collapsed completely on compression with the transducer probe and augmented with distal compression were chosen for AVF construction. Any thickening or thrombosis was duly observed and noted.

The arteries were similarly mapped; the radial artery at the wrist & the brachial artery along the medial aspect of the arm. The ulnar artery was not routinely mapped in the presence of an adequate radial artery flow. The depth,

diameter & flow were noted across the arteries. A note was made of any excessive calcification or irregularity of the vessel wall. A site for the access procedure was then chosen after correlating the clinical findings with the visual impression as seen on the Duplex scan. The AVF construction was carried out by the same vascular surgeon, under optimum conditions. Patients were then followed up in the post- operative period upto the time of successful AVF cannulation for Haemodialysis, wherein the AVF was termed successful.

Statistical methods:

The distribution of the various predictor variables was analyzed using tabular displays and histograms. We used the odds ratios (with 95% confidence intervals) to compare these variables and the chi-square test to determine the compatibility of data with hypotheses of no association. Multivariable logistic regression methods were used to model associations between multiple predictor variables and AVF maturation. We constructed Receiver Operating Characteristic (ROC) curves by plotting sensitivity versus specificity of our model predicting AVF maturation. The area under the ROC curve and the odds ratios were utilized for predicting optimum venous & arterial diameters for AVF construction.

RESULTS:

A total of 80 patients were included in the study, out of which 43 were male and 37 female.

The mean age was 49.68 years, with a minimum age of 18 and a maximum of 78 yrs.

Age, sex, ESRF, HTN, DM & duration of disease had no significance in predicting a successful AVF.Proximal brachiocephalic AVF construction was carried out in 34 patients while distal radiocephalic AVF construction was done in 27 patients. In addition, brachio-basilic vein transposition AVFs were constructed in 19 patients.

The overall AVF patency rate was 60 %. Patency rates were highest in brachiobasilic AVFs (89.50%), while brachiocephalic & radiocephalic AVFs had patency rates of 47.10% & 55.60% respectively. Using Pearson's Chi- Square test (with continuity correction), no significant association was found between final outcome and vein diameter in each type of AVF. Also, the type of AVF constructed was not a significant predictor of successful AVF, when compared using binary logistic regression.

RRT was already being carried out in 55 patients (either HD or PD) at the time of creation of the fistula. HD was being carried out by Internal Jugular Vein (IJV) catheterization in 53 Dialysis (CAPD). However, 25 patients were not on any form of dialysis. Of those being dialyzed, 55 patients (68.8%) gave history of previous central venous catheterization (CVC). This is significant in view of central venous stenosis caused by prior CVC, which may lead to venous outflow obstruction. A history of prior central venous catheterization was obtained in 68.8 % patients.

Studies [3] have found subclavian and internal jugular stenosis in patients on temporary HD catheters. This is an important cause of venous outflow obstruction and subsequently, AVF failure. Majority of the patients had ESRF, Hypertension (HTN) and Diabetes Mellitus (DM). However, no significant association was found between these comorbid illnesses and the final outcome as per binary logistic regression.

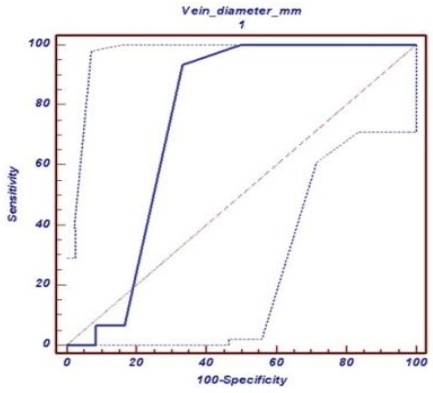
Previous central venous catheterization, brachial artery diameter, proximal cephalic vein diameter and distal basilic vein flow

velocity were found to be significant predictors of a successful AVF using binary logistic regression.

Using the ROC curves (Table 1), it was found that a distal vein diameter of ≥ 2.2 mm was a significant predictor of a working AVF, with a 95% confidence interval of 0.547 to 0.895, and an area under the ROC curve of 0.750. Positive likelihood ratio was 2.8, while negative likelihood ratio was 0.1, which was significant.The odds ratio derivatives suggest that, a vein having a diameter of ≥ 2.2mm was 4 times more likely to yield a patent fistula.
Furthermore, using the ROC curve, it was found that a proximal arterial diameter ≥ 3mm was found to be a significant predictor of the final outcome, with 95% Confidence intervals of 0.566 to 0.824 & an area under the ROC curve of 0.707. Positive likelihood ratio was 1.75, while negative likelihood ratio was 0.39, which was significant. Using odds ratio, an artery having a diameter of ≥ 3 mm was 3 times more likely to yield a patent fistula.

Discussion:

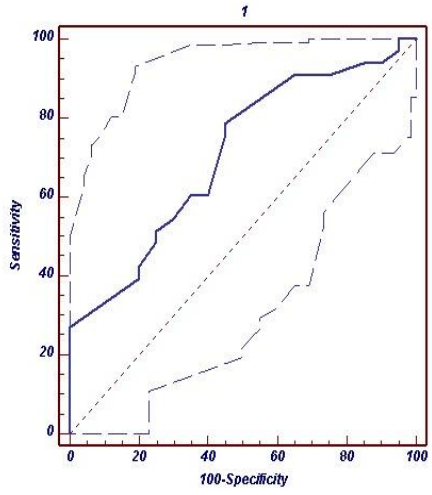
1).Sex-wise AVF maturation differences:
Women usually have smaller arteries and veins and, therefore, this may be the reason for poorer maturation and survival rates of vascular access in them. However, the literature remains contradictory. Some studies have shown that there was no difference in the arterial and venous diameters between males and females, with similar maturation and 1-year patency rates; whereas others have shown that that female gender was associated with an increased use of grafts and a higher number of access revisions. [4-10, 17]
However, our study showed no significant association between sex and the final outcome (successful AVF maturation), as confirmed by binary logistic regression.

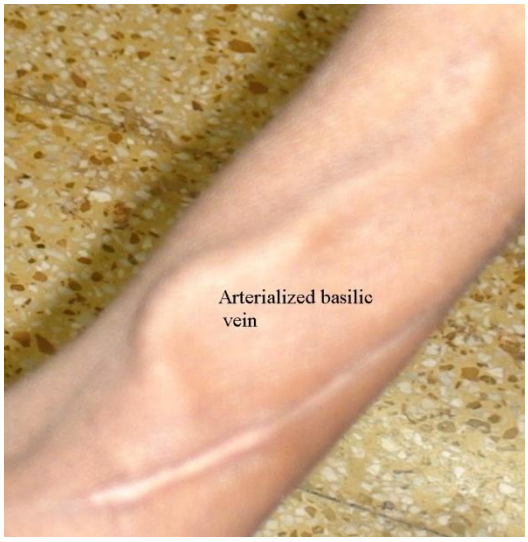


2). Age- wise distribution:

The mean age was 49.68 years, with a minimum age of 18 and a maximum of 78 yrs. Age may have an influence on post-operative blood flow in newly created autogenous fistulae, which results in a slightly higher failure rate as compared with young patients.[9]

No significant association was found between age and final outcome, as per binary logistic regression.





Arterial Diameter - mm

3). Comorbid illnesses (Diabetes Mellitus, Hypertension, ESRF, Others):

The combination of age and diabetes does have an impact on fistula outcome with significantly higher failure rates and an increased percentage of grafts in elderly patients. [10- 12] Our study did not show any significant association between the two and the final outcome.

The presence of diabetes and hypertension may have an additional negative impact on the chance of successful access creation. These patients usually have poor, thickened and calcified arteries with proximal and/or distal vessel obstruction.[12-15] Access creation is more difficult, and the risk of symptomatic ischaemia of the upper and lower extremity due to access-induced steal syndrome is significant.

Hypotension is a well-known cause of thrombosis of a vascular access. In some studies, hypertension was found to be protective against AVF failure [13].

In a retrospective study of 191 patients, Thomsen et al[16] described a greater early failure rate (first 4 weeks after placement) in patients with low perioperative systolic blood pressure (110 mm Hg; 53% versus 24%; P <0.02). These findings suggest that consideration should be given to evaluating strategies in which antihypertensive therapy is deintensified around placement of an AVF.

In this study, Diabetes Mellitus and Hypertension did not affect the final outcome. Also, no significant association was found between Diabetes Mellitus and the final outcome in each category of venous diameter. No discernible cause was found. However, more cases need to be included to study this causal association.

4). Association between Final Outcome and Vein diameter:

Preoperative vascular mapping has shown to substantially increase the total proportion of patients dialyzing with fistulae [17-19]. Several studies support the 2.0- to 2.5-mm vein diameter threshold for successful creation of a fistula. Radiocephalic fistulae constructed in veins with a less than 2.0-mm diameter had only 16% primary patency at 3 months compared with 76% for those with veins greater than 2.0 mm[17]. In a pivotal study [9], a threshold of 2.5 mm vein diameter assessed by duplex ultrasound was used. This resulted in an increase in fistula creation of 63% compared with a retrospective 14% rate in the absence of vascular mapping [20]. A similar study using the same duplex ultrasound criteria showed a fistula increase from 34% in historical controls to 64%. Importantly, in this study, duplex ultrasound altered the surgical plan based entirely on the surgeon's clinical evaluation, resulting in increased placement of fistulae[21].

Although angiography remains the standard for evaluating the central veins, they may be assessed indirectly by using duplex

ultrasound[12]. Compared with invasive venography, duplex ultrasound had a specificity of 97% and sensitivity of 81% for detecting central vein occlusion[20]. Alternatively, Magnetic Resonance Angiography may be used for evaluation of central venous occlusion[21, 22].

In our study, an overall AVF patency of 60 % was achieved, with brachiobasilic vein transposition fistulae having the maximum patency rates of 89.50% (17 working out of 19), while radiocephalic AVFs had a patency rate of 55.60 %(15 working out of 27). Brachiocephalic AVFs had the poorest patency rate of 47.10 % (16 working out of 34).

In the present study, a distal vein diameter of ≥ 2.2 mm was a significant predictor of a working AVF, with a 95% confidence interval of 0.547 to 0.895, & an area under the ROC curve of 0.750. Positive likelihood ratio was 2.8, while negative likelihood ratio was 0.1, which was significant.

The odds ratio for distal venous diameter was 4.008, which meant that an AVF created using a venous diameter ≥2.2mm was 4 times more likely to succeed as compared to that using a vein with lesser diameters.

Also, a proximal arterial diameter ≥ 3mm was found to be a significant predictor of a working AVF, with confidence intervals of 0.566 to 0.824 & an area under the ROC curve of 0.707. Positive likelihood ratio was 1.75, while negative likelihood ratio was 0.39, which was significant.

An odds ratio of 3.02 signified that arterial diameter of ≥ 3mm was 3 times more likely to produce a patent AVF.

This study showed no significant association between the final outcome and vein diameter in each type of AVF.

Also, the type of AVF was not a significant predictor of the final outcome (working AVF).

This study showed that previous central venous catheterization, brachial artery diameter (mm), proximal cephalic vein diameter (mm) & distal basilic vein flow velocity (cm/sec) were significant predictors of working as final outcome.

Table 1

ROC Curve for vein diameter (mm) as a predictor of final outcome (working AVF):

Variable	Vein diameter (mm)
Classification Variable	Final outcome
Select	1
Positive group	
Final outcome	= 1
Sample size	15
Negative group	
Final outcome	= 0
Sample size	12
Disease prevalence (%)	unknown
Area under the ROC curve	0.750
Standard error	0.094
95% Confidence interval	0.547 to 0.895
Significance level P (Area= 0.5)	0.0079

Table: 2
Association between Final Outcome and Vein diameter (mm)

Final Outcome		Vein diameter (mm) (ROC cut-off)		Total
		>2.2	≤2.2	
Working	No.	41	7	48
	%	68.30%	35.00 %	60.00 %
Not working	No.	19	13	32
	%	31.70%	65.00 %	40.00 %
Total	No.	60	20	80
	%	100.00%	100.0 0%	100.0 0%

Chi-square Tests	Value	df	p-value	Association is-
Pearson Chi-Square	6.944	1	0.008	Significant
Continuity Correction	5.625	1	0.018	Significant

Risk Estimate	Value	95% Confidence Interval	
		Upper	Lower
Odds Ratio for Final Outcome (Working / Not working)	**4.008**	1.378	11.658
For cohort Vein diameter (mm) (ROC cut-off) ≥ 2.2	1.439	1.056	1.96
For cohort Vein diameter (mm) (ROC cut-off) ≤ 2.2	0.359	0.161	0.801

Table: 3
ROC Curve for proximal arterial diameter (mm) as predictor of final outcome (working AVF):

Variable	Arterial diameter (mm)
Classification variable	Final outcome
Select	1
Positive group	
Final outcome	= 1
Sample size	33
Negative group	
Final outcome	= 0
Sample size	20
Disease prevalence (%)	unknown
Area under the ROC curve	0.707
Standard error	0.071
95% Confidence interval	0.566 to 0.824
Significance level P (Area=0.5)	0.0037

Table: 4

Association between Final Outcome and Arterial diameter (mm)

Final Outcome		Arterial diameter (mm) (ROC cut-off)		Total
		>3	≤ 3	
Working	No.	26	22	48
	%	74.30 %	48.90 %	60.00 %
Not working	No.	9	23	32
	%	25.70 %	51.10 %	40.00 %
Total	No.	35	45	80
	%	100.00 %	100.00 %	100.00 %

Chi-square Tests	Value	df	p-value	Association is-
Pearson Chi-Square	5.291	1	0.021	Significant
Continuity Correction	4.286	1	0.038	Significant

Risk Estimate	Value	95% Confidence Interval	
		Upper	Lower
Odds Ratio for Final Outcome (Working / Not working)	3.02	1.16	7.866
For cohort Arterial diameter (mm) (ROC cut-off) ≥ 3	1.926	1.044	3.552
For cohort Arterial diameter (mm) (ROC cut-off) ≤3	0.638	0.438	0.929

Conclusion:

Pre- operative Colour Doppler imaging of the arterio- venous system, coupled with utilization of optimal arterial & venous cut-off diameters can be helpful in improving the success rate of AV Fistulae.

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Corresponding Address:

Dr. Neemesh Manohar Lodh, Department of Surgery, B K L Walawalkar Rural Medical College and Hospital, Sawarde, Taluka- Chiplun, District- Ratnagiri. Pin: 415606.Maharashtra, India.
E-mail address: neemeshl@gmail.com