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# Vessel Diameter and Impact on Management of Failed Fistulas in Patients of End Stage Renal Disease on Hemodialysis

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## Abstract

**Background:** To evaluate the different modalities of surgical procedures in the treatment of failed vascular accesses for hemodialysis. With regards to the confounding variables like age, gender, comorbid conditions, arterial and vein diameter and the primary/secondary patency of the procedures.

**Methods:** A prospective study was carried out on 60 patients of end stage renal disease with failed primary vascular access between 14 to 70 years of age. The patients were evaluated by clinical arterial pulse and vein examination supplemented by Duplex scan of both arterial and venous system to evaluate for the present vascular access. The patients were followed up for a minimum of 6 months (maximum of 18 months) after the secondary procedure. Descriptive statistical analysis has been carried out using SPSS software.

**Results:** Mean radial artery diameter was found to be 2.2 mm and mean brachial artery diameter was found to be 4.0 mm in diameter.23 out of 60 patients (38.3%) with failed AVF had radial arterial diameter of less than 2 mm. The mean cephalic vein diameter at the level of wrist was found to be 2.2 mm and mean cephalic vein diameter at elbow was found to be 2.9 mm. Radio cephalic Arterio venous fistula was positively correlated with good functional outcome when the cephalic vein diameter exceeds 2 mm. (p value = 0.096).

**Discussion:** Preoperative duplex scan improves the outcome of the AV fistula. Radial artery > 2 mm and cephalic vein diameter > 2 mm along with healthy palpable pulse are predictable parameters for a successful outcome of an AV fistula at wrist.

***Keywords:*** *Vascular access; Failed fistula; Diameter of radial artery and Cephalic vein*

## Introduction

Chronic kidney disease (CKD) is an important, non communicable disease that affects the world, including India. The true magnitude of CKD/end-stage renal disease (ESRD) is unknown. Renal replacement therapy is a term used to encompass life-supporting treatments for renal failure that includes hemodialysis, peritoneal dialysis, hemo filtration, and renal transplantation. After the introduction of hemodialysis in 1944, there has been a dramatic increase in the long term survival of patients with chronic kidney disease. India has approximately 100 Renal Transplant centers, mostly in private setup, and not more than 3000 to 4000 Renal Transplants are performed annually. Thus, only 3% to 5% of all patients with ESRD in India get some form of renal replacement therapy [1].

The surgeons have continuously faced the challenge of designing the "ideal access" for hemodialysis on a long term basis. During the last two decades, native Arterio venous fistula has evolved as the preferred access as per KDOQI guidelines and the initiatives of Fistula first organization [2,3]. The Vascular Access Work Group of the National Kidney Foundation (NKF) has opined that quality of life and overall outcomes for hemodialysis patients could be improved significantly by achieving two primary goals: (a) increase the placement of autogenous arteriovenous (AV) fistulae; and (b) detecting access dysfunction prior to access failure [3,4]. It has been suggested that

the order of access preference is radio-cephalic fistula, followed by brachio-cephalic fistula [3,4]. Arterio-Venous grafts and permanent indwelling tunneled catheters are indicated in selected subgroup of patients as an alternative.

Missed dialysis is not only responsible for the morbidity but also implicated in accelerated mortality. Failing fistulas need urgent attention to rescue the patency. Due to lack of standardized vascular access surveillance program or protocol, we receive the patients with failed access for hemodialysis. The patients often need to have their dialysis postponed or rescheduled, or they may have to undergo emergency placement of temporary central venous dialysis catheter to obtain the access for dialysis until the fistula can be repaired or a new access created. This accounts for the major cause of re-hospitalization of patients of chronic kidney disease, having emotional, social, and financial implications.

**Aim and Objectives:**

a. To evaluate the different modalities of surgical procedures in the treatment of failed vascular accesses for hemodialysis.
b. To evaluate the effects of vessel size on long term secondary patency of the arterio venous fistula.

## Material and Methods

A prospective study was carried out on 60 patients of end stage renal disease with failed primary vascular access between 14 to 70 years of age. Children below 14 years of age, patients with adverse cardio respiratory conditions unsuitable for anesthesia, and the patients of peripheral vascular disease are excluded from the study. Details such as history of diabetes, hypertension, and use of tobacco in any form, significant illness, onset of renal disease, type of renal replacement therapy, prior vascular access surgery, and duration of the prior access patency are collected. The patients are evaluated by clinical examination followed by duplex scan of the arterial and venous system of the selected extremity. For secondary AVF creation, standard recommended methods are adopted giving priority to the autogenous fistulas. The patients are followed for a minimum of 6 months at monthly intervals for evaluation of the access patency and the complications.

Descriptive statistical analysis has been carried out in the present study. Chi-square/Fisher Exact test was used to find the significance of study parameters on categorical scale between two or more groups. 95% Confidence Interval has been computed to find the significant features. Confidence Interval with lower limit more than 50% was associated with statistical significance.

## Results and Discussion

The age and gender distribution of the patients of end stage renal disease show a male preponderance with mean age of presentation to be around 46 years. The left radio cephalic fistula was the preferred primary access procedure for the surgeons providing the primary vascular access for the purpose of hemodialysis (73.3%). 40 out of 60 (66.7%) patients of failed AV access were found to be non diabetic. 27 patients were on single antihypertensive drugs and 20 were on two antihypertensive drugs for the control of hypertension.40 out of 60 patients were not using tobacco in any form 10 years before the procedure.

The patients were clinically evaluated for the consideration of functioning vascular access, assisted by duplex scan. The left brachio cephalic AV fistula was the most commonly performed secondary AV access procedure (30 out of 60 cases). Thrombectomy was attempted in 2 of the failed fistulas. Synthetic Arterio venous PTFE (Brachial artery –Axillary vein) graft was placed in a looped fashion in 2 two patients, under general anaesthesia. Closure of the AV fistula was done in 2 cases with infection and pseudoaneurysm at the site of previous anastomosis. Single case of *Ulnar*-basilic AV fistula was carried out.

Mean radial artery diameter was found to be 2.2 mm and mean brachial artery diameter was found to be 4.0 mm in diameter 23 out of 60 patients (38.3%) with failed AVF had radial arerial diameter of less than 2 mm and cephalic vein to be less than 2 mm.

| Radial parameters | Number of patients (n = 60) | %age | Mean ± SD |
|---|---|---|---|
| Radial Artery Diameter (mm) | | | |
| 1.0-2.0 | 23 | 38.3 | 2.22 ± 0.43 |
| 2.1-3.0 | 36 | 60.0 | |
| > 3.0 | 1 | 1.7 | |
| Brachial Artery Diameter (mm) | | | |
| < 3.0 | 3 | 5.0 | 4.03 ± 0.91 |
| 3.1-4.0 | 31 | 51.7 | |
| 4.0-5.0 | 18 | 30.0 | |
| > 5.0 | 8 | 13.3 | |
| Cephalic Vein Diameter (mm) | | | |
| 1.1-2.0 | 23 | 38.3 | 2.20 ± 0.52 |
| 2.1-3.0 | 34 | 56.7 | |
| > 3.0 | 3 | 5.0 | |
| Cephalic Vein at Elbow (mm) | | | |
| < 2.0 | 3 | 5.0 | 2.95 ± 0.99 |
| 3.1-4.0 | 35 | 58.3 | |
| 3.1-4.0 | 16 | 26.7 | |
| > 4.0 | 6 | 10.0 | |

***Table 1:*** *Upper limb Vessel diameter in duplex imaging in patients with failed primary fistula.*

| Failure of Primary LRC/RRC | Number of patients (n = 60) | Cephalic Vein diameter at Wrist | |
|---|---|---|---|
| | | < 2 mm (n = 14) | > 2 mm (n = 46) |
| Yes | 54 (90.0%) | 13 (92.9%) | 41 (89.1%) |
| No | 6 (10.0%) | 1 (7.1%) | 5 (10.9%) |

***Table 2:*** *Correlation of failure of primary Left or right Radio cephalic AV fistula with Cephalic Vein diameter at wrist*

On retrospective analysis, the cephalic vein diameter at wrist < 2 mm was not found to be statistically associated with failure of primary AV fistula. The non-functional AV fistula was found to have thrombosed cephalic vein with an increase in diameter compared to a patent cephalic vein. This may be correlated with the discrepancy of positive functional outcome of a secondary AV fistula with > 2 mm cephalic vein diameter at wrist to the failure of primary AV fistula with > 2 mm cephalic vein diameter.

| Secondary procedure | Number of patients (n = 60) | Cephalic Vein diameter at Wrist | |
|---|---|---|---|
| | | < 2 mm (n = 14) | > 2 mm (n = 46) 1 |
| LRC/RRC | 14 (23.3%) | 0 (0%) | 14 (30.4%) |
| THROMBECTOMY | 2 (3.3%) | 0 (0%) | 2 (4.3%) |
| CLOSURE OF AVF | 2 (3.3%) | 0 (0%) | 2 (4.3%) |

***Table 3:*** *Secondary procedure and Cephalic Vein diameter at Wrist in patients with failed primary fistula.*

Left or right radio cephalic fistula is significantly associated with > 2 mm of cephalic vein diameter at wrist with P = 0.096 + x

| Failure of Primary LRC/RRC | Number of patients (n = 60) | Radial artery diameters | |
|---|---|---|---|
| | | < 2 mm (n = 23) | > 2 mm (n = 37) |
| Yes | 54 (90.0%) | 22 (95.6%) | 32 (86.5%) |
| No | 6 (10.0%) | 1 (4.3%) | 5 (13.5%) |

***Table 4:*** *Correlation of failure of primary Left or right radio cephalic fistula with radial artery diameter.*

The failure of primary LRC/RRC fistula is statistically positively associated with radial artery diameter of < 2 mm diameter (95.6% versus 86.5% with a p value = 0.391)

| Secondary procedure | Number of patients | | Function | |
|---|---|---|---|---|
| | No | % | Present | % |
| Left Brachio cephalic Fistula (LBC) | 30 | 50.0 | 26 | 86.7 |
| Right Radio cephalic fistula (RRC) | 14 | 23.3 | 12 | 85.7 |
| Right brachio cephalic fistula (RBC) | 9 | 15.0 | 8 | 88.9 |
| Thrombectomy | 2 | 3.3 | 1 | 50.0 |
| Lt brachio axillary graft | 2 | 3.3 | 2 | 100.0 |
| Closure of fistula | 2 | 3.3 | 0 | 0.0 |
| Rt ulno basilic fistula | 1 | 1.7 | 1 | 100.0 |
| Total | 60 | 100.0 | 50 | 83.3 |

***Table 5:*** *Secondary procedure and outcome in patients with failed primary fistula.*

| Risk factors | Outcome | | Univariate Analysis | | |
|---|---|---|---|---|---|
| | Functioning (n = 50) | Non-Functioning (n = 10) | OR | 95% CI | P value |
| Age > 50 years | 23 (46.0%) | 5 (50.0%) | 1.17 | 0.3-4.6 | NS |
| Male | 40 (80.0%) | 8 (80.0%) | 1.00 | 0.2-5.5 | NS |
| Multiple Primary access | 6 (12.0%) | 2 (20.0%) | 1.83 | 0.3-10.7 | 0.610 |
| Ipsilateral IJV catheter | 12 (24.0%) | 0 | - | - | 0.188 |
| DM | 17 (34.0%) | 3 (30.0%) | 0.83 | 0.2-3.6 | NS |
| Hypertension | 49 (98.0%) | 10 (20.0%) | - | - | NS |
| Smoking/Tobaco | 20 (40.0%) | 0 | - | - | 0.023* |
| Clinical Vein Mapping (< 3 mm) | 17 (34.0%) | 3 (30.0%) | 0.83 | 0.19-3.63 | 1.000 |
| Dimished Pulse character | 21 (42.0%) | 6 (60.0%) | 2.07 | 0.52-8.27 | 0.296 |

***Table 6:*** *Correlation of Risk factors with Functioning or non-function of AV access at first follow up using Multivariate logistic regression analysis.*

On individual secondary procedure related functional analysis we found Left Brachio cephalic Fistula (LBC) (86.7%), Right Radio cephalic fistula (RRC) (85.7%), and Right brachio cephalic fistula (RBC) (88.7%) to function satisfactorily. Creating an AV fistula proximally in a suitable site considering clinical and imaging findings can provide an equivalent unassisted patency of the AV fistula. Thrombectomy was successful in one out of 2 patients attempted (50%). Left Brachio axillary graft and *Ulnar*-basilic AVF was successful in 3 out of 3 cases (100%). However statistical significance cannot be drawn of these 3 results. The functioning of LBC, RRC, and RBC is positively associated with p value of 0.177. Overall, secondary AV access functionality was attained in 50 out of 60 patients (83.3% of cases).

On multivariate logistic regression analysis we found smoking/tobacco not to be associated with functioning of AVF (p value = 0.023). However thrombosis of AV access, uncorrected is associated with non-functioning of AV fistula (p value < 0.001) .Age though is associated with increased atherosclerotic changes with calcific blood vessels were found to be non-associated with decreased functionality of AVF. Males predominating the secondary procedure have 80% functional vascular access. 17 out of 50 patients had diabetes with functional vascular access (34%). Majority of hypertensive patients had functional vascular access (98.0%) which is statistically insignificant. 20 out of 50 patients had history of smoking in the last 10 years. The functional outcome and tobacco smoking was found to be statistically significant with a p value of 0.023. Cephalic vein evaluation on clinical basis was disappointing to assess the functionality of AV fistula. Diminished pulse character, though provides a good clinical guidance to predict the outcome of a fistula was not having statistically significant association with functioning outcome.

The primary patency of the AV access created at first follow up is around 81. 6 % (49/60) at first follow up. The assisted primary patency of the AV access at first follow up is around 83.3 % (59/60), contributed by the successful thrombectomy of the Brachiocephalic outlet thrombosis in the perioperative period.

## Discussion

### Age and Gender

Allon., *et al*. found that female gender was the only independent predictor of decreased likelihood of fistula maturation [6]. In contrast, Prischl., *et al*. found no significant differences in access survival between 80 men and 43 women on hemodialysis with first AVF [7]. The different findings of these studies perhaps can be explained by the small sample sizes and the fact that the populations were derived from single center. In our present analysis, we found no relation between age, gender and primary or, secondary patency and primary failure rate. We found that gender has no impact on fistula survival, wherever the site of creation, a finding that was not matched with some recent reports indicating that women had poorer distal AVF survival [8, 9]. This could be explained by the high incidence of manual works in our female patients. With regard to age and access patency several reports have failed to find any association between age and access complications although others reported a significant effect of age appearing after 6 months of follow-up [10,11,12].

### Primary and Secondary Arterio Venous Access

Patients presenting acutely with renal failure have poorer AVF patency, which may be linked to the need for temporary access via a central venous catheter. The risk of requiring three or more vascular accesses is almost double amongst the patients who start hemodialysis treatment using a central venous catheter [13].

Although the prevalence of patients with an AVF is high (60% to 80%) in Canada, Japan, and Europe, AVFs account for only 21% to 28% of vascular access in the United States, where more than 50% of patients have grafts and permanent catheters are widely used [14,15]. In our study, patients of ESRD on dialysis presented to us with failed Arterio venous fistula only. This can be correlated well to the preferred use of autogenous fistula and less use of synthetic grafts in India for the purpose of dialysis. The present study the prevalence of failed left radio cephalic AV fistula, either alone (73.3%) or in association with other access procedures is 87.3%. This indicates that the left side, being the non dominant hand is the preferred primary vascular AV access site. Majority of the times, the patients

present to the hospital in neglected and failed stage of failed fistula. This may be correlated to the lack of a proper vascular access surveillance programme. Taking various factors into consideration, we have preferred to create a more proximal Arterio venous access site instead of revising the already failed access. In 30 out of 60 patients, we have created brachial cephalic fistula in the left upper limb.

**Diabetes and Hypertension**

Garrancho and colleagues [15] have found higher incidence of fistula failure in patients with Diabetes Mellitus. According to Field., *et al*. [16] Fistula survival rates in non-diabetics patients were higher than in patients with diabetes. However, this was not significant (p = 0.11); (54, 48 and 34% in diabetics compared to 45, 35 and 26% in non-diabetics at 6, 12 and 24 months, respectively .In our study, we could not find statistical significant association between the Diabetes and the access dysfunction. (OR 0.83, C I = 0.2-3.6). Out of 60 cases20 patients had diabetes (33. 3%). 17 out of 20 cases had functional AV fistula. Singh., *et al.* [17] have stressed on securing a proximal AV fistula for improving the outcome in diabetic ESRD patients. In 15 out of 20 cases, we have created a proximal secondary vascular access; of which 11 are functional. This explains higher success rates in diabetic ESRD patients undergoing a proximal AV fistula. The primary patencies of the access created are more than 6 months on follow up.

**Diameter of Radial Artery, Cephalic Vein, and Fistula Patency**

Small arteries and veins have higher initial failure rates, more frequent failure to mature and poorer long-term patency. It has been suggested that a cut-off of 2 mm for both the arterial and venous diameters should be used [18]. A smaller artery could limit the flow in through the fistula because of the strong influence of the radius ($1/r^4$) on the pressure drop. Whilst in most cases it is possible qualitatively to assess the vessel size and to recognize the presence of thrombosis, in patients who are obese or have deep lying veins, this is difficult to accomplish since the veins are not readily visible or palpable. High resolution ultrasound color flow scanners can provide non-invasive and quantitative data on the vessel size and blood flow velocity prior to and following the operation.

Wong V., *et al*. [19] have evaluated the Factors associated with early failure of arteriovenous fistulae for haemodialysis access. Radial artery and cephalic vein diameter less than 1.6 mm were associated with early fistula failure. The intraoperative fistula blood flow did not correlate with the outcome of the operation probably due to vessel spasm from manipulation either thrombosis or failure to maturation. In all RC AVFs created in patients with a radial artery diameter of < 1.6 mm In another study, successful RC AVFs had a pre-operatively measured radial artery diameter of 2.7 mm vs. 1.9 mm in failed RC AVFs [23]. Malovrh discriminated between RC AVF created with radial arteries, with a diameter > 1.5 mm vs 1.5 mm. Immediate patency rate in the > 1.5 mm group was 92 vs 45% in the 1.5 mm group, while the patency rates after 12 weeks were 83% vs 36%, respectively [20]. Venous imaging Vein diameters of < 1.6 mm have been associated with AVF failure [22] while good patency rates were obtained in patients with RCAVFs where the diameter of the cephalic vein at the wrist was > 2–2.6 mm or upper arm veins > 3 mm) [28]. The cephalic vein diameter increase after application of a proximal tourniquet is an important predictor of success. In a group of successfully created AV fistulae, the vein diameter increased by 48%, while vein diameter only increased by 11.8% in the group of failed AV fistulae [25,26,27].

In the present study, the failure of primary LRC/RRC is statistically positively associated with Radial artery diameter < 2 mm (95.6% vs 86.5%) with p = 0.391. We have avoided creating wrist AV fistula when the diameter of the radial artery is less than 2 mm. The functioning of the LRC/RRC is significantly associated with > 2 mm of cephalic vein diameter at wrist with P = 0.096+. The results are in accordance with the findings obtained in the other studies.

## Conclusion

We have found the following points for recommendation for improving the outcome form our study.

1. Preoperative duplex scan improves the outcome of the AV fistula.
2. Radial artery > 2 mm and cephalic vein diameter > 2 mm along with healthy palpable pulse are predictable parameters for a successful outcome of an AV fistula at wrist.
3. Creating a proximal fistula is a rewarding option for patients with failed vascular access with an unfavorable arterio-venous anatomy in the duplex scan.

4. In diabetic patients, it is better to consider for a proximal ac fistula for better outcome.

5. We need to have more of comparative studies to opine regarding the smaller biometrics of the blood vessels in Indian patients, especially Asian population in comparison to the western world. Early placement of native A-V fistulae, early start for access planning, early referral to the nephrologists, abolishing subclavian vein canulation, peritoneal dialysis as bridge therapy helps in fistula outcome. Effective pharmacological inhibition of intimal hyperplasia, use of better biomaterials with multidisciplinary approach to vascular access management are the other areas of interest that need to be looked upon

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