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Outcomes Following Longitudinal and Transverse Arteriotomy in Distal Radiocephalic Arteriovenous Fistula Surgery

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Abstract

Background: Arteriovenous fistulas (AVFs) are the preferred method for hemodialysis access in patients with end-stage renal disease (ESRD). This study aimed to compare the outcomes of longitudinal versus transverse arteriotomies in distal radiocephalic AVF creation, focusing on patency, failure rates, and postoperative complications.

Methods: A prospective, randomized, comparative study was conducted over 12 months. Fifty patients were randomly assigned to undergo either a longitudinal (Group A) or transverse (Group B) slit arteriotomy during distal radiocephalic AVF creation. Preoperative and postoperative data, including patient demographics, comorbidities, and Doppler ultrasound measurements of arterial and venous diameters, were recorded. Patency and failure rates were assessed at 6 months, and postoperative complications were monitored.

Results: The mean age of participants was 45.9 ± 10.8 years, with a male predominance (72%). The primary and secondary patency rates were slightly higher in the longitudinal arteriotomy group, but these differences were not statistically significant ($P > 0.05$). The primary failure rate was lower in the longitudinal group (32%) compared to the transverse group (36%), and the secondary failure rate was higher in the transverse group (16%) compared to the longitudinal group (4%), though these differences were also not statistically significant. Postoperative complications, including thrombosis and infection, were comparable between groups. A significant increase in the diameters of both the radial

artery (P = 0.000) and cephalic vein (P = 0.000) was observed postoperatively.

Conclusion: This study found no statistically significant differences in patency, failure rates, or complications between longitudinal and transverse arteriotomy techniques for distal radiocephalic AVF creation. Both techniques resulted in similar outcomes, suggesting that the choice of arteriotomy may not significantly impact short-term fistula function. Further research with larger sample sizes and longer follow-up is needed to assess the long-term effects of arteriotomy technique on AVF outcomes.

Keywords: Arteriovenous fistula, Arteriotomy, Chronic kidney disease, Complications, Dialysis, Longitudinal, Patency, Transverse.

Introduction

Arteriovenous fistulas (AVFs) are the lifeline to patients with end stage renal disease (ESRD) who are on hemodialysis; however, they are also the Achilles heel of a chronic hemodialysis program.[1] Arteriovenous fistulas (AVFs) are surgically created connections between native arteries and veins, providing a reliable access for hemodialysis by allowing the necessary blood flow rates for effective filtration. In an AV fistula, blood flows directly from the artery into the vein, increasing both the pressure and the volume of blood through the vein. This elevated flow and pressure cause the veins to enlarge. As a result, the enlarged veins are able to accommodate the blood flow required for effective hemodialysis treatment. AV fistulas are the preferred vascular access for long-term dialysis due to their durability, lower risk of infection and clotting, and consistent performance.[2-3]

Although native arteriovenous fistulas (AVFs) generally have a low complication rate, early failure within the first month has been reported in up to 29% of patients in some studies. During this period, prolonged hemodialysis through a percutaneous catheter may be necessary while the fistula matures, increasing the risk of infection and compromising central vein patency.[4-7]

While there are reports demonstrating the success of end-to-side vascular anastomoses using longitudinal arteriotomies, one study suggested that transverse arteriotomy may be preferable form small vessels. Transverse arteriotomy is easier to perform, produces less raggedness around the edges for suturing, and allows for a quicker completion of the anastomosis compared to longitudinal arteriotomy. The faster and simpler execution of the anastomosis with transverse arteriotomies may also help reduce the risk of stenosis by minimizing the duration of clamp time. Additionally, using an ellipsoid incision to estimate the length and tissue removal may result in an excessive defect.[8-9]

The purpose of this study was to determine if there was greater stenosis or more turbulence associated with longitudinal versus transverse arteriotomies via identifying the primary patency, secondary patency, primary failure, secondary failure and complications associated with AVF placement.

Materials and Methods

The study was designed as a prospective, randomized, comparative study for a duration of 12 months. Patients with Chronic kidney disease, referred from Nephrology Department who were allotted for the distal radiocephalic arteriovenous fistula surgery as per the inclusion and exclusion criteria.

Sampling method: A systematic randomization was applied to the patients who underwent distal radiocephalic arteriovenous fistula (RC-AVF) creation surgery in the Department of Plastic and Reconstructive Surgery. The patients were assigned serial numbers from

1 to 50 based on the date of their surgery. Two groups were formed: Group A, consisting of patients with odd serial numbers, underwent longitudinal slit arteriotomy, while Group B, consisting of patients with even serial numbers, underwent transverse slit arteriotomy during the surgery. All procedures were performed by a single resident surgeon.

Sample size: 50 cases

Methodology

The baseline characteristics of the patients, including age, gender, etiology of renal disease, duration of hemodialysis, hand dominance, and BMI, were recorded. Additional information, such as preoperative blood pressure, catheter use and duration, associated comorbidities, as well as data regarding the radial artery and cephalic vein diameter, and the time course of maturation, was collected from the medical records of the enrolled patients. Routine investigations required before surgery such as complete blood count, random blood sugar, prothrombin time, viral markers which includes hepatitis A surface antigen, anti-hepatitis C antibody, human immunodeficiency virus were done. Patients also underwent ultrasound Doppler of the upper limb preoperatively and postoperatively.

Operative procedure

The distal RC-AVF was created under local anesthesia on a day-case basis. A horizontal incision was made at the wrist, followed by venous dissection using sharp scissors with minimal handling of the veins. After ligating and dividing the distal end of the cephalic vein, heparin was injected into the divided vein. Radial artery dissection was performed by incising the fascia and clearing the artery of adventitia. Microvascular clamps were then applied to the proximal and distal ends of the radial artery. In Group A, a longitudinal slit arteriotomy was made, while in Group B, a transverse slit arteriotomy was performed. Dilatation of both the arteriotomy and venotomy was carried out using a dilator. The end of the cephalic vein was then anastomosed to the radial artery in an end-to-side fashion using 7-0 polypropylene interrupted sutures. After confirming hemostasis, the vein was palpated for the presence of a thrill, and the skin was closed. The patient was discharged on the same day following the surgery.

Follow up

Patients were followed up at 1 week to evaluate early postoperative complications, and subsequently at 4 weeks and 6 weeks to assess the suitability for dialysis cannulation. For hemodialysis suitability, the AVF needed to support two-needle use and maintain a blood flow rate of >300 ml/min for at least eight hemodialysis sessions over a 1-month period. A Doppler ultrasound was performed at 4 weeks postoperatively to confirm suitability for cannulation. Afterward, patients were instructed to return for monthly follow-up visits for up to 6 months following surgery.

Definitions:[10]

1. Primary patency- (intervention - free access survival) was defined as the interval from time of access placement to any intervention designed to maintain or reestablish patency or to access thrombosis or the time of measurement of patency.
2. Secondary patency- Time from AVF creation to access abandonment.
3. Primary failure defined as permanent failure of AVF before hemodialysis suitability. This included maturation, thrombosis, failure of first and subsequent cannulations, and other complications leading to non-functional AVFs.

4. Secondary failure defined as permanent failure after the AVF met dialysis suitability criteria with subsequent abandonment.

Inclusion criteria

1. Patients planned for their first distal RC-AVF
2. Patients planned for distal RC-AVF with cephalic and radial artery diameter >2.0mm
3. Patients planned for distal RC-AVF in age group of 18-60 years
4. Patients who consented to participate in the study

Exclusion criteria

Patients with failed initial distal RC-AVF, proximal RC-AVF, brachiocephalic and brachiobasilic fistulas.

Statistical analysis

Data obtained was entered in Microsoft excel sheet and analysis was done using SPSS (Statistical package for Social Sciences) version 2020. The quantitative data was expressed in mean and standard deviation and the categorical data was expressed in frequencies and percentages. The appropriate test of significance was applied.

Results

The mean age of the patients was 45.9 ± 10.8 years, with a range from 21 to 64 years. Among the participants, 72% were male and 28% were female. All the patients were right hand dominant. The average Body Mass Index (BMI) was 22.12 ± 3.66 kg/m². Regarding the etiology of renal disease, the most common cause was hypertension (42%), followed by hypertension with diabetes mellitus (22%) and glomerulonephritis (14%). Other causes included polycystic kidney disease (8%), multiple myeloma (2%), a combination of polycystic kidney disease and hypertension (2%), and diabetes mellitus alone (10%).The mean systolic blood pressure was 149.66 ± 10.7 mmHg, and the mean diastolic blood pressure was 88.08 ± 10.2 mmHg. The average duration of catheter use was 2.36 ± 0.52 weeks, and the mean time on dialysis was 4.54 ± 2.03 weeks. (Table 1)

Table 1: Characteristics of the patients included in the study

S N	Characteristics	N=50
1	Mean Age in years	45.9 ± 10.8[a]
2	Gender	
	Male	36(72%)[b]
	Female	14 (28%)[b]
3	Body Mass Index (BMI) (Kg/m^2)	22.12 ± 3.66[a]
4	Etiology of renal disease	
	Hypertension	21(42%)[b]
	Hypertension & DM	11(22%)[b]
	GN	7(14%)[b]
	PCKD	4(8%)[b]
	MM	1(2%)[b]
	PCKD &HTN	1(2%)[b]
	DM	5(10%)[b]
5	Blood pressure (mmHg)	
	Systolic BP	149.66 ± 10.7[a]
	Diastolic BP	88.08 ± 10.2[a]
6	Use of catheter (weeks)	2.36 ± 0.52[a]
7	Time on dialysis (weeks)	4.54 ± 2.03[a]

[a]mean ± standard deviation, [b]Frequency (percentage), DM-Diabetes mellitus, GN-Glomerulonephritis, PCKD-Polycystic kidney disease, HTN- Hypertension, MM-Multiple myeloma, BP – Blood pressure

We compared the patency rates at 6 months between longitudinal and transverse arteriotomy techniques. A total of 50 patients participated, with 25 undergoing longitudinal arteriotomy and 25 undergoing transverse arteriotomy. Although the primary (68%) and secondary patency rates (64%) were generally higher in the longitudinal arteriotomy group, these differences were not statistically significant.

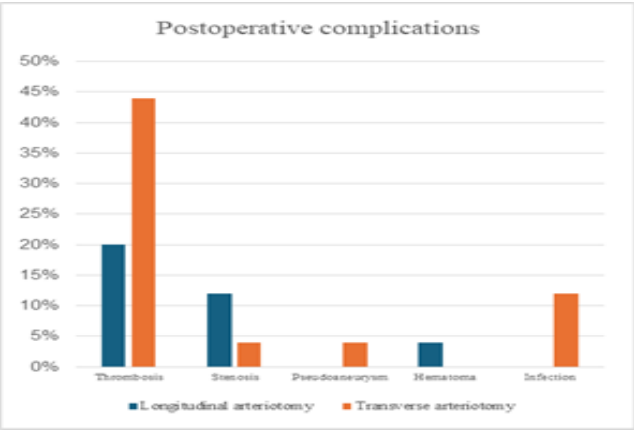
Similarly, the primary failure rate was lower (32%) in the longitudinal arteriotomy group compared to the transverse group (60%), but this difference was not statistically significant either. The secondary failure rate was higher in the transverse arteriotomy group (16%) compared to the longitudinal group (4%), though this difference was also not statistically significant. (Table 2)

Table 2: Comparison of arteriotomy types with respect to patency and failure rates

Sn.	Characters	Longitudinal arteriotomy (n=25)	Transverse arteriotomy (n=25)	p-value*
1	Primary patency (at 6 months)	17 (68%)	15(60%)	0.384
2	Secondary patency (at 6 months)	16 (64%)	14(56%)	0.387
3	Primary failure	8 (32%)	9(36%)	0.500
4	Secondary failure	1 (4%)	4 (16%)	0.174

* Test applied- Chi square test

Figure 1: Post operative complications depending upon the type of arteriotomy among the patients



The mean diameter of the radial artery was 2.62 ± 0.53 mm preoperatively and slightly increased to 2.66 ± 0.47 mm postoperatively. The change in the radial artery diameter was statistically significant with a p-value of 0.000.

The mean diameter of the cephalic vein increased substantially from 2.36 ± 0.52 mm preoperatively to 3.50 ± 1.44 mm postoperatively. This change was also statistically significant with a p-value of 0.000.

Table 3: Mean difference between the diameters of the arteries and veins preoperative and postoperative Doppler USG.

Doppler USG	Mean ± SD	P-value
Radial artery (mm) Preoperative Postoperative	 2.62 ± 0.53 2.66 ± 0.47	0.000*
Cephalic vein (mm) Preoperative Postoperative	 2.36 ± 0.52 3.50 ± 1.44	0.000*

*Test applied – paired t test. P value <0.05 indicates statistically significant.

Discussion

In this prospective study, the mean age of the study participants was 45.9 ± 10.8 years between 21 to 64 years, 72% were male gender and 42% had hypertension followed by 22% had both hypertension and Diabetes mellitus and 14% had glomerulonephritis as the cause for renal disease, and the mean BMI was 22.1 ± 23.66 kg/m^2. In Huijbregts, H. J et al, the mean age of the study participants was 64.6 ± 14.2 years, 62% male gender, 33% had diabetes and 23% had coronary artery disease as cause for renal disease. The mean BMI was 25.1 ± 4.5kg/m^2 which was synonymous to our present study.[10] In the cohort study conducted by Fitzgerald JT

et al, mean age of 56 years and a nearly 60% rate of diabetes mellitus.[11]

Patency rates and failure rates

In our study, we compared the patency rates at 6 months between longitudinal and transverse arteriotomy techniques. A total of 50 patients participated, with 25 undergoing longitudinal arteriotomy and 25 undergoing transverse arteriotomy. Although the primary (68%) and secondary patency rates (64%) were generally higher in the longitudinal arteriotomy group, these differences were not statistically significant. Similarly, the primary failure rate (32%) was lower in the longitudinal arteriotomy group compared to the transverse group (60%), but this difference was not statistically significant either. The secondary failure rate was higher in the transverse arteriotomy group (16%) compared to the longitudinal group (4%), though this difference was also not statistically significant. These results suggest that while longitudinal arteriotomy might offer some potential benefits in terms of patency, the differences between the two methods were not statistically significant in this study.

Although there are no similar studies specifically comparing the type of arteriotomy for AVF, other research provides relevant insights. For instance, in a 3-year study by Golledge et al.,[12] 107 consecutive patients underwent the formation of a radiocephalic fistula (RCF) for permanent hemodialysis access. The median follow-up period was 24 months, with endpoints including access failure, transplantation, or death. Patients who received prosthetic, ulnar, brachial, or secondary fistulas were excluded from the study. The primary patency rates were 69% at 12 months and 56% at 24 months. Endovascular and surgical interventions showed limited improvement in secondary patency. The authors concluded that one-third of RCFs fail irreversibly within two years.

In Huijbregts, H. J et al.,[10] 18-month secondary functional patency was somewhat higher at 86% (median 960 d) versus 77%. An informative experimental study on arteriotomies was conducted by Nam et al.,[13] who performed various longitudinal slit and elliptical incisions and measured blood flow post-operatively. Neither the shape of the arteriotomy nor the angle at which the smaller vessel was anastomosed onto the host vessel made any significant difference to the blood flow. Similar observations based on patency rates were made in arterio-venous anastomoses by Brennan and O'Brien.[9]

Reduced overall patency of distal radiocephalic fistulas may be due to increasing endothelial damage and development of intimal hyperplasia and stenosis due increased hemodynamic stresses experienced by the anastomoses.

Complications

In our study, postoperative complications in patients who underwent transverse arteriotomy included thrombosis (44%), infection (12%), and pseudoaneurysm (4%). In contrast, patients who underwent longitudinal arteriotomy experienced thrombosis (20%), stenosis (12%), and hematoma (4%). These differences were not statistically significant. Additionally, none of the patients developed steal syndrome.

In a study conducted by Schinstock, C. A et al.,[14] eighty-two complications resulting from AVF creation occurred in 21.2% of patients. Specifically, 16% of AVFs had only one complication, 3.8% had two complications, and 1.3% had three or four complications. Complications included bleeding (33.0%, 27 of 82), infection(26.8%,22

of 82), steal syndrome (18.3%, 15 of 82), aneurysm(8.5%, 7 of 82), thrombosis (4.9%, 4 of 82), seroma(4.9%, 4 of 82), subclavian stenosis (2.4%, 2 of 82),and nerve injury(1.2%, 1 of 82).

The most frequent cause of failure not amenable to reintervention was thrombosis; 13(15%) patients had this complication, and only 1 regained secondary patency.

Additionally, in the present study, the mean difference in the diameters of the arteries and veins between preoperative and postoperative Doppler ultrasound measurements was statistically significant, with a p-value <0.05. These findings suggest that both the radial artery and cephalic vein experienced significant changes in diameter following the surgical procedure, indicating a successful adaptation of the vessels for use in hemodialysis. The statistically significant increase in vessel diameters postoperatively supports the effectiveness of the AVF creation procedure in improving the suitability of these vessels for hemodialysis access.

Conclusion

In conclusion, our study found no statistically significant differences in patency and failure rates between longitudinal and transverse arteriotomy techniques for distal radiocephalic arteriovenous fistula creation. Although the longitudinal arteriotomy group demonstrated higher primary and secondary patency rates and a lower primary failure rate, these differences did not reach statistical significance. Our findings are consistent with previous studies suggesting that factors such as endothelial damage, initial hyperplasia, and hemodynamic stress may contribute to the overall reduced patency of distal radiocephalic fistulas. Further research with larger sample sizes and longer follow-up periods is needed to establish definitive conclusions regarding the impact of arteriotomy technique on long-term fistula outcomes.

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