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A PROSPECTIVE STUDY OF ARTERIOVENOUS FISTULA CREATION IN PATIENTS WITH CHRONIC RENAL FAILURE IN INDEX MEDICAL COLLEGE HOSPITAL & RESEARCH CENTRE, INDORE (M.P)

Surgery

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ABSTRACT

Background: Arteriovenous (AV) fistulas are naturally occurring connections between an artery and a vein that enable for adequate blood flow during hemodialysis in patients with chronic renal failure. Compared to grafts, they have higher rates of patency and fewer complications. In order to achieve hyperdynamic circulation and ensure that regular venous access is not an issue, AV fistula are created at various levels. The presents study sought to determine factors influencing the patency rate of AV fistulas, postoperative complications, and the success rate of AV fistulas. **Materials and Methods:** After approval from the IEC, this prospective study was conducted in Department of General Surgery of Index Medical College Hospital & Research Centre, Indore on 100 patients of all age groups and both gender who visited the OPD with diagnosis of chronic kidney disease. A written pre-informed consent was taken from all patients before enrollment. **Result:** Out the 100 patients enrolled in the study, majority i.e., 63% revealed radiocephalic fistulas while 12% had brachiocubital fistulas. 80% of patients were treated by doing side-to-side anastomosis, while in rest 20% patients, end-to-side anastomosis was done. The AV fistula remained patent in 65 (65%) patients, and among them, the patency rate of radiocephalic was 60% and that of brachiocephalic was 13.8%. The patency rate for side-to-side fistula was 83.1% and that for end-to-side was 16.9%. Patency rate for patients with hemoglobin (Hb) > 9 g % was 93.85% with only 6.15% for patients with Hb < 9 g %. Nonsmokers were 3.5 times (95% CI: 1.58–8.23) more likely to have patent fistula than smokers. Arterial diameter is also a predictor of patency. **Conclusion:** The success rate of AV fistula by conventional vascular anastomosis technique was 65%. Side-to-side anastomosis showed higher patency rate than end-to-side anastomosis. Radiocephalic AV fistula had better patency rate than other types of fistulas performed in upper limb. Anemia (Hb < 9 g %), smoking, and arterial diameter were the major factors influencing patency of fistula. Thrombosis, surgical site infection, postoperative edema, aneurysm and steal phenomenon were the complications noticed in the postoperative period.

KEYWORDS

Arteriovenous (AV) fistula, side-to-side anastomosis, chronic renal failure, hemodialysis.

INTRODUCTION

Patients with chronic renal failure (CRF) who are expected to need hemodialysis treatment are treated with fistulas and grafts. Autogenous arteriovenous or AV fistula (AVF) is a type of vascular access which involves a direct connection between an artery and a vein. It allows the flow of arterial blood through the vein. This results in venous engorgement and swelling, enabling sufficient blood flow for hemodialysis at a rate of 600 mL/min.[1]

Brescia and Cimino published their landmark article on hemodialysis using an autologous AVF in 1966, greatly reducing the issues with infection and thrombosis that plagued the previously described long-term cannulation techniques and external shunts.[2] It is now well known that autogenous vascular access has higher rates of patency and fewer complications than transplants.[3]

There are many various ways to create an AVF, but we have primarily created fistulas in the hand and forearm regions without the use of an interposition or graft. AVF failure reduces the number of sites at which another access can be performed in addition to interrupting a functional access. In order to save the failing AVFs, the patients must also undergo interventional treatments. It is crucial to understand the risk factors for AVF failure and the potential side effects of AVF implantation.[4]

In advent of study, the present study was aimed to study and compare the success rate of AV fistula (AVF) done by conventional vascular anastomosis technique. Further we also studied and assessed the complications and their incidences and the factors affecting the patency rate of AVF.

MATERIALS AND METHODS

After approval and review from the institutional ethical committee, this present prospective follow-up study was conducted in Department of General Surgery, Index Medical College Hospital & Research Centre Indore from August 2019 to July 2021. A total of 100 patients with Chronic renal failure (CRF) were enrolled for the study after taking informed written consent from the patients after explaining them the purpose of the study. Those patients who gave informed written consent were included in the study

The data collection tool included sociodemographic variables, clinical variables, inclusion criteria, and variables on follow-up of the patients.

Inclusion Criteria

- Patients of age between 18 and 70 years and of both genders with chronic kidney disease;
- Patients with Hb ≥ 7.5 g %; visible, palpable, and compressible (thrombus free) vein was included.
- Patients with systolic blood pressure ≥ 100 mm Hg and diastolic blood pressure ≥ 70mm Hg were also included in the study.

Exclusion Criteria

- Patients with coronary artery disease (CCF and history of myocardial infarction, angioplasty, or CABG); amputation as a result of peripheral artery occlusive disease;
- Patients with coagulopathy (history of deep vein thrombosis or pulmonary embolism);
- Hb < 7.5 g %; hypovolemia; septicemia; veins <3 mm diameter; and arteries <2 mm diameter were excluded from the study.[5]

Type of Fistulas Performed

Although many types of AVFs are described, we have mainly performed radiocephalic fistulas (cimino -Brescia) and brachiocubital fistulas. Other types of fistulas included in this study were brachiocephalic, brachiobasilic, radiocubital, and cubitocephalic

fistulas (in case of failure of brachiocephalic fistula).

Success Parameter and the Follow-Up Schedule

The success of the procedure was considered as when successful dialysis from the vein can be done after 30 days of the procedure. The patients were followed-up on 7, 15 and 30 days and were assessed for patency of fistula. The postoperative complications were also recorded.

Procedure

In the present study, the nondominant extremity was chosen more than the dominant extremity and the forearm was chosen more than arm for construction of an AVF. Diameters of the vessels were measured before the procedure by Ultrasound and Venous mapping arterial Doppler was done in all patients. AVFs are routinely created under local anesthesia (2% xylocaine), which is instilled at the site of incision. Skin incision of appropriate size was kept at the preoperatively marked site, and the skin flaps were elevated. Artery and vein were identified, dissected, and mobilized. Heparin (3000 units) was given subcutaneously or intravenously before occluding the artery. After applying clamps, arteriotomy and venotomy were made. Vein was distended with saline, and then, anastomosis of the two vessels was created by prolene 6-0 suture continuously.

Success of the procedure was decided by, that is, palpable thrill/audible bruit/palpable pulsation in vein soon after the surgery and by continuous wave Doppler examination of AVF and oxygen saturation of the hand. Patients were discharged next day. If there was oozing from the wound or hematoma, only those patients were kept under observation for (1–2 days)

Statistical Analysis

The data was initially captured in the customized proforma and the transferred to Microsoft excel for analysis. Statistically Software IBM SPSS Version 20.0.0.0 was used for calculating the P values. Descriptive statistics was presented in the form of numbers and percentages. Comparison of mean between more than two groups was done using One Way ANOVA. A p value of <0.05 was taken as statistically significant. The final data was presented in the form of tables and graphs.

RESULTS

The study was done on 100 patients of chronic renal failure (CRF) who qualified the inclusion criteria, in whom we have made different types of AVFs. The mean age of the patients was 45.5 (±12.5) years, with a median of 46 years and a range of 14 to 70 years. Table 1 show that out of the total 100 patients, majority (34%) of the patients belonged to age group between 41 and 50 years; followed by 24% patients belonging to 31–40 years of age. The patency rate of the fistula was highest (35.4%) in the age group of 41–50 years. Patency rates in other age groups were 26.2% in 31–40 years; 21.5% in 51–60 years; and 13.8% in 21–30 years, and the lowest rate (3.1%) was found in the age group of 61–70 years.

Of the 100 patients included in the study, 65 (65%) were male and 35 (35%) female subjects. The success rates in both the genders were 67.7% in male and 32.3% in female subjects, but this difference was statistically insignificant. (p>0.05). The failure rates of AVF were 60% and 40%, in male and female subjects, respectively.

Table 1: Age-wise and gender-wise distribution of patients along with the success rate of AV fistula

	Patient n (%)	Failure n (%)	Total n (%)
Age groups			
21–30	9 (13.8)	3 (8.6)	12 (12)
31–40	17 (26.2)	7 (20)	24 (24)
41-50	23 (35.4)	11 (31.4)	34 (34)
51–60	14 (21.5)	9 (25.7)	23 (23)
61–70	2 (3.1)	5 (14.3)	7 (7)
Total	65 (100)	35 (100)	100 (100)
Gender			
Male	44 (67.7)	21 (60)	65 (65)
Female	21 (32.3)	14 (40)	35 (35)
Total	65 (100)	35 (100)	100 (100)

Out of the 100 AVFs (Table 2) performed, 63 (63.0%) were radiocephalic fistulas, followed by 12 (12%) brachiocubital fistulas and 9 (9%) brachiocephalic fistulas among the other types. Other types of fistulas included brachiobasilic [8 (8.0%)], radiocubital [5 (5%)], and cubitocephalic [3 (3%)]. On assessing the patency of 100 fistulas, 65 (65%) fistulas were patent. Among the 65 patent fistulas, the patency rate of radiocephalic fistula was 60.0%, followed by brachiocephalic (13.8%) and by brachiocubital fistulas (10.8%).

Regarding the type of the anastomosis, 80 (80%) AVFs were side-to-side fistulas and 20 (20%) end-to-side fistulas. In reference to the type of anastomosis, the patency rate of side-to-side anastomosis was higher 54 (83.1%) than that of the end-to-side anastomosis 11(17.4%). This difference was statistically insignificant (p> 0.05).

Table 2: Types of AV fistula and its proportion among total AV fistula and its patency rates

	Patent n (%)	Failure n (%)	Total n (%)
Type of anastomosis according to site			
Radiocephalic	39 (60)	24 (68.6)	63 (63)
Brachiocubital	7 (10.8)	5 (14.3)	12 (12)
Brachiocephalic	9 (13.8)	0 (0)	9 (9)
Brachiobasilic	5 (7.7)	3 (8.6)	8 (8)
Radiocubital	3 (4.6)	2 (5.7)	5 (5)
Cubitocephalic	2 (3.1)	1 (2.9)	3 (3)
Total	65 (100)	35(100)	100 (100)
Type of anastomosis according to technique			
Side-to-side	54 (83.1)	26 (74.3)	80 (80)
End-to-side	11 (16.9)	9 (25.7)	20 (20)
Total	65 (100)	35 (100)	100(100)

Table 3: Factors affecting patency of AV fistulas

	Patent	Failure	Total
Smoking habit, n (%)			
Nonsmoker	38 (58.4)	14(40)	52 (52)
Smoker	27 (41.6)	21(60)	48 (48)
Total	65(100)	35(100)	100(100)
Anemia, n (%)			
Anemic (hemoglobin <9 g %)	4 (6.15)	8 (22.85)	12 (12)
Nonanemic (hemoglobin ≥9 g %)	61 (93.85)	27 (77.15)	88 (92)
Total	65(100)	35(100)	100(100)
Arterial diameter (mm)			
Mean	3.284	2.785	
Standard deviation	0.76	1.18	

Independent sample t-test between arterial diameter in millimeter and patency					
Levene's test for equality of variances		t-Test for equality of mean values			
F	Significance		df	P	Mean difference
2.578	0.0002*	2.347	41	0.022	0.479

Table 4: Complications after AV fistula (*n* = 42)

Complications	No. of patients (%)
Thrombosis	17 (36.9)
Postoperative edema	13 (28.2)
Infection	9 (20)
Ischemia owing to steal phenomenon	5 (10.8)
Aneurysm	2 (4.1)
Total	46 (100)

As demonstrated in Table 3, of the 100 CRF patients, 52% were nonsmokers and 48% smokers. Failure rates among smokers (60%) was higher than that in nonsmokers (40%), and this difference was statistically significant (p= 0.001). This study found that nonsmokers were 3.5 times [95% confidence interval (CI): 1.58–8.23] more likely to have their fistula patent than smokers. As shown in Table 3, 88 (92%) patients were with Hb ≥ 9 g % and 12 (12 %) patients with Hb ≤ 9 g %. Patients with anemia were 4.5 (95% CI: 1.5–13.7) times more likely experienced AVF failure than patients who were nonanemic (p < 0.003).

As demonstrated in Table 3, on applying t-test between arterial diameter (in mm) and patency, arterial diameter was found to be significantly higher in those with patent AVFs (3.284 ± 0.76) than those with nonpatent AVFs (2.785 ± 1.18) [t (41) = 2.347, p = 0.022].

In patients on hemodialysis, hemorrhage, low venous flow, or hematoma may occur immediately after surgery, while complications

such as infections, development of an aneurysm and/or false aneurysm, fistula vein stenosis, steal syndrome and thrombosis occur at a later stage. As seen from Table 4, among the complications found in this study, the most common complication was thrombosis (36.9%). It can be diminished by appropriate handling of vessels during the surgery. Infection (20%) can be prevented by pre and post operative shots of antibiotics. Postoperative edema (28.2%) can be reduced by strict elevation of limb. Extraluminal compression by edema, hematoma, or seroma may lead to stenosis.[6] This simple measure prolongs the patency of fistula. Steal phenomenon and aneurysm were the least common complications encountered, but they demand regular follow-up and revision of surgery when indicated.

DISCUSSION

In this study, the mean age of the patients with CRF was 45.5 (±12.5) years with median of 46 years. The results of our study were comparable to previous studies done by Mittal et al.[6], Dash & Agarwal et al.[7] & Dekhaiya et al.[8] In a study done by Mittal et al.,[6] the median age was 43 years (range 10 days to 90 years). As per study done by Dash and Agarwal[7] the mean age among the patients with CRF was 42.38 (±12.54) years, which is nearly consistent. Dekhaiya et al.[8] in his study also found that the results were promising in patients between 41 and 50 years of age.

Although male gender is more prone to smoking and vessel wall damage, the patency rate was better among the male gender. The reason for this preponderance is not known, and this finding is also supported by other studies.[2]

In our study, patency rate was found to be highest in radiocephalic type of AVF as this anastomosis is done in the anatomical snuff box at the wrist of the hand, in which the radial artery and cephalic vein are close by. So, there is less mobilization and handling of the vessels, leading to lesser chances of edema and vessel wall damage. This in turn leads to better flow and higher patency rate.

End vein-side artery anastomosis is associated with long-term patency and lower rate of venous hypertension in hand,[9] but in our study, we found that side-to-side anastomosis had more patency rates which was in concurrence with study done by Dekhaiya et al.[8] This finding may also be because of bigger diameter of the anastomosis itself.

Anemia is a well-known factor that affects healing, in general. In our study, patients with anemia (Hb < 9 g %) showed less patency rate of fistula. This was similar to study done by Dekhaiya et al.[8]

Among the complications found in this study, the most common complication was thrombosis (36.9%). The most common cause of vascular access thrombosis is venous neointimal proliferation.[10] Neointimal hyperplasia is the proliferation of smooth muscle cells under the influence of basic fibroblast and platelet-derived growth factors. The smooth muscle cell layer penetrates through the internal elastic lamina and then migrates into the intima. During migration, they are modified into a secretory from a contractile type, which produces a basic substance that cause intimal fibrosis.[11]

Moreover, fibrinogen has been found in an increased concentration in patients on chronic HD, which activates platelets and increases further platelet deposition. Adherent platelets release platelet-derived growth factor to initiate intimal hyperplasia, thereby reducing blood flow.[12,13] Moreover, damage to the blood vessel walls during the procedure exposes the subendothelial structures to blood flow and initiates a hemostatic reaction, resulting in the formation of a thrombus.[14]

In a study done by Leon C et al., 1.6%–8% of patients developed unilateral ischemia of the hand owing to steal syndrome,[15] which was in contrast to our study where an incidence of 10.8% was reported which was similar to study done by Dekhaiya et al.[8] who reported an incidence of 11.6%. It may arise from excessive blood flow through a dilated blood vessel together with insufficient vascular adaptation and reduced collateral perfusion. This ischemia may require amputation of fingers and/or forearm. Prevention of it includes adequate preoperative assessment, use of Doppler ultrasound, a precise surgical technique that involves arteriotomy no greater than 7 mm, and being within the range of a 90–180^0 angle of anastomosis.[5]

In our study, infection accounted for 9% of cases which was similar to incidence as reported by Dekhaiya et al.[8] They reported an incidence of 5.33% of cases. While in the study by Schild et al.[16], fistula infection rate was 0.9%. Most AVF infections involve perivascular cellulitis, which manifests as localized erythema and edema and is usually easily treated. However, hematomas or abscesses may require surgical intervention.

In our study, the arterial diameter was found to be significantly higher in those with patent AVFs than those with nonpatent AVFs. It is favored by few facts that the more the diameter of the artery, the less the technical difficulties during the procedure. With a 1-mm increase in arterial diameter, the risk of AVF abandonment decreased by 30% over a median follow-up of 379 days. This effect of artery size may be because: (1) blood flow is proportional to the fourth power of the arterial radius, and, thus, small increments in size may substantially increase flow; and (2) larger arteries may exhibit a greater vasorelaxant response, thereby accommodating greater blood flow during AVF maturation.[4]

Age and gender are well-known factors affecting the success of AVF and has been found as a cofounder in almost all researches across the globe. Ironically, in this study too, a conclusive reason was not interpreted for the higher patency rate in the age group of 41–50 years. In addition, gender was not a significant contributor to the success rate of AVF in our study. This was comparable to study done by Dekhaiya et al.[8]

Tendency for atherosclerosis, blood pressure levels, heart rate, and size of arteriovenous anastomosis are the other confounding factors that might be affecting the outcome of the study and thus we recommend future researches to study these factors. Further, we have tried our best to attend to known confounders by excluding renal failure patients with certain characteristics, which are mentioned in the exclusion criteria.

CONCLUSION

The results of this study suggest that AVF can be created as the initial permanent access in the majority of the patients with end-stage renal disease. Exceptions to this practice were patients with serious risk of aggravating preexisting chronic heart failure or causing a symptomatic steal syndrome according to the preoperative clinical assessment. In addition, it is imperative to gain knowledge about early clinical symptoms of AVF dysfunction to prevent and adequately treat potential complications.

It was concluded from the study that AVFs created in younger age have higher patency rates. Radiocephalic AVFs show better patency rate for dialysis in CRF patients. The side- to-side anastomosis reveals better patency than the end-to- side anastomosis. Factors affecting the failure of AVF include anemia, atherosclerosis, thrombus formation, and smoking. Thrombus formation, edema, steal phenomenon and surgical site infection were the complications encountered after the procedure in our study. Arterial diameter is also a predictive factor of AVF patency.

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