Research Article

A prospective study of arteriovenous fistula creation in chronic renal failure patients in Bhavnagar, Gujarat, western India

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Abstract

Background: Arteriovenous (AV) fistula is an autogenous connection between an artery and a vein, which allows adequate blood flow during hemodialysis in patients with chronic renal failure, and they have superior patency rates and lower complication rates than grafts.

Objective: To study the success rate of AV fistula, postoperative complications, and factors affecting the patency rate of AV fistula.

Materials and Methods: This prospective study was conducted in Department of General Surgery of Sir Takhtsinhji Hospital, Bhavnagar, Gujarat, India, during 2012–2014 in patients of all age groups and both gender with chronic kidney disease.

Result: Of the 150 patients enrolled in the study, 62% revealed radiocephalic fistulas while 17% brachiocubital fistulas. In majority of the patients (81%), side-to-side anastomosis was done, while in 19% patients, end-to-side anastomosis was done. The AV fistula remained patent in 115 (77%) patients, and among them, the patency rate of radiocephalic was 60% and that of brachiocephalic was 13%. The patency rate for side-to-side fistula was 83% and that for end-to-side was 18%. Patency rate for patients with hemoglobin (Hb) > 9 g % was 94% with only 6% for patients with Hb < 9 g %. Nonsmokers were 3.6 times (95% CI: 1.58–8.23) more likely to have their fistula patent than smokers. Arterial diameter is also a predictor of patency.

Conclusion: The success rate of AV fistula by conventional vascular anastomosis technique was 77%. Side-to-side anastomosis showed better patency rate than end-to-side anastomosis. Radiocephalic AV fistula showed better patency rate than other types of fistulas performed in upper limb. Anemia (Hb < 9 g %), smoking, and arterial diameter were the major factors affecting fistula patency. Thrombosis, postoperative edema, surgical site infection, steal phenomenon, and aneurysm were the complications noted in the postoperative period.

KEY WORDS: Arteriovenous fistula, side-to-side anastomosis, chronic renal failure, hemodialysis, western India

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Introduction

Fistulas and grafts are used for patients with chronic renal failure (CRF) who are expected to need hemodialysis treatment. Autogenous arteriovenous or AV fistula (AVF) is a type of vascular access involving a direct connection between an artery and a vein. This surgical procedure is usually performed on an outpatient basis. It allows the flow of arterial blood through the vein. This causes venous engorgement and enlargement, allowing adequate blood flow at the rate of

600 mL/min for hemodialysis.[1] In 1966, Brescia and Cimino recorded their milestone article on hemodialysis using an autologous AVF, greatly decreasing the problems of infection and thrombosis, which beset the long-term cannulation methods and external shunts described previously.[2] Now, it has been well established that autogenous vascular access have superior patency rates and lower complication rates than grafts.[3]

There are many different options for AVF creation, but we have mainly performed fistulas in forearm and hand region without an interposition/graft. Failure of an AVF not only interrupts a functional access but also reduces the number of sites at which another access can be made. In addition, subjecting the patients to interventional procedures is required to salvage the failing AVFs. Therefore, it is important to identify the risk factors for AVF failure and to define the complications that may occur after AVF placement.[4]

The objectives of the study were to study success rate of AVF done by conventional vascular anastomosis technique, to study the complications and their incidences, and to study the factors affecting the patency rate of AVF.

Materials and Methods

Study Design and Setting

This prospective follow-up study was conducted in Department of General Surgery, Sir Takhtsinhji Hospital, Bhavnagar, from 2012 to 2014. This hospital is a tertiary-care district hospital of Bhavnagar catering to a sizable population around it. A total of 150 patients with CRF were enrolled in the study.

Data Collection Tool

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

Ethical Issue

Informed written consent was taken from the patients after explaining them the purpose of the study. Those patients who gave informed written consent were included in the study. Permission for conducting the study was taken from the institutional review board of our institute.

Inclusion Criteria

Patients of age between 18 and 70 years and of both genders with chronic kidney disease; Hb ≥ 7.5 g %; visible, palpable, and compressible (thrombus free) vein were included. Patients with systolic blood pressure ≥ 100 mm Hg and systolic 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; 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 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 is 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 our study, we chose the nondominant more than dominant extremity and the forearm more than arm for construction of an AVF. Diameters of the vessels were measured before the procedure by ultrasound and by Castroviejo callipers during the procedure. 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 (5,000–10,000 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 7-0 suture in a simple continuous manner.

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 operated on day care basis. If there was oozing from the wound or hematoma, only those patients were kept under observation for few hours to 1–2 days.

Results

The study included 150 patients of CRF who met the predecided inclusion criteria, in whom we have made different types of AVFs. The mean age of the patients was 46.5 (±13.5) years, with a median of 47 years and a range of 18 to 70 years.

Table 1 show that, of the total 150 patients, majority (34%) of the patients belonged to age group between 41 and 50 years; followed by 25.3% patients belonging to 31–40 years of age. The patency rate of the fistula was highest (32.2%) in the age group of 41–50 years. Patency rates in other age groups were 26.9% in 31–40 years; 19.1% in 51–60 years; and 14.8% in 21–30 years, and the lowest rate (2.6%) was found in the age group of 61–70 years.

Of the 150 patients included in the study, 98 (65.3%) were male and 52 (34.7%) female subjects. The success rates in both the genders were 66.1% in male and 33.9% in female subjects, but this difference was statistically insignificant

(χ^2 = 0.124, p = 0.725). The failure rates of AVF were 62.9% and 37.1%, in male and female subjects, respectively.

As illustrated in Table 2, of the 150 AVFs performed, 93 (62.0%) were radiocephalic fistulas, followed by 17 (11.3%) brachiocubital fistulas and 15 (10%) brachiocephalic fistulas among the other types. Other types of fistulas included brachiobasilic [12 (8.0%)], radiocubital [8 (5.3%)], and cubitocephalic [5 (3.3%)]. On assessing the patency of 150 fistulas, 115 (76.6%) fistulas were patent. Among the 115 patent fistulas, the patency rate of radiocephalic fistula was 60.0%, followed by brachiocephalic (13%) and by brachiocubital fistulas (10.4%).

Regarding the type of the anastomosis, 121 (80.7%) AVFs were side-to-side fistulas and 29 (19.3%) end-to-side fistulas. In reference to the type of anastomosis, the patency rate of side-to-side anastomosis was higher (82.6%) than that of the end-to-side anastomosis (17.4%). This difference was statistically insignificant (χ^2 = 1.19, p = 0.274).

As elucidated in Table 3, of the 150 CRF patients, 52% were nonsmokers and 48% smokers. Failure rates among smokers (71.4%) was higher than that in nonsmokers (28.6%), and this difference was statistically significant (χ^2 = 10.03, p = 0.001). This study found that nonsmokers were 3.6 times [95% confidence interval (CI): 1.58–8.23] more likely to have their fistula patent than smokers. As shown in Table 3, 135 (90%) patients were with Hb ≥ 9 g % and 15 (10%) 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 (χ^2 = 8.38, 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 (3.204 ± 0.73) than those with nonpatent AVFs (2.715 ± 1.17) [t(42) = 2.337, p = 0.024].

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 (33.33%). It can be diminished by appropriate handling of vessels during the surgery. Infection (19.04%) can be prevented by pre- and postoperative shots of antibiotics. Postoperative edema (30.95%) 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.

Table 1: Age-wise and gender-wise distribution of patients along with the success rate of AV fistula (n = 150)

	Patient, μ (%)	Failure, μ (%)	Total, μ (%)
Age groups			
21–30	17 (14.8)	3 (8.6)	20 (13.3)
31–40	31 (26.9)	7 (20)	38 (25.3)
41–50	37 (32.2)	14 (40)	51 (34)
51–60	22 (19.1)	11 (31.4)	33 (22)
61–70	3 (2.6)	5 (14.3)	8 (16)
Total	115 (100)	35 (100)	150 (100)
Gender			
Male	76 (66.1)	22 (62.9)	98 (65.3)
Female	39 (33.9)	13 (37.1)	52 (34.7)
Total	115 (100)	35 (100)	150 (100)

Table 2: Types of AV fistula and its proportion among total AV fistula and its patency rates (n = 150)

	Patient, μ (%)	Failure, μ (%)	Total, μ (%)
Type of anastomosis according to site			
Radiocephalic	69 (60)	24 (68.6)	93 (62)
Brachiocubital	12 (10.4)	5 (14.3)	17 (11.3)
Brachiocephalic	15 (13)	0 (0)	15 (10)
Brachiobasilic	9 (7.8)	3 (8.6)	12 (8)
Radiocubital	6 (5.2)	2 (5.7)	8 (5.3)
Cubitocephalic	4 (3.5)	1 (2.9)	5 (3.3)
Total	115 (100)	35(100)	150 (100)
Type of anastomosis according to technique			
Side-to-side	95 (82.6)	26 (74.3)	121 (80.7)
End-to-side	20 (17.4)	9 (25.7)	29 (19.3)
Total	115 (100)	35 (100)	150 (100)

Table 3: Factors affecting patency of AV fistulas (*n* = 150)

	Patient	Failure	Total
Smoking habit, *n* (%)			
Nonsmoker	68 (59.1)	10 (28.6)	78 (52)
Smoker	47 (40.9)	25 (71.4)	72 (48)
Total	115 (100)	35 (100)	150 (100)
Anemia, *n* (%)			
Anemic (hemoglobin <9 g %)	7 (6.08)	8 (22.85)	15 (10)
Nonanemic (hemoglobin ≥9 g %)	108 (93.91)	27 (77.14)	135 (90)
Total	115 (100)	35 (100)	150 (100)
Arterial diameter (mm)			
Mean	3.204	2.715	
Standard deviation	0.73	1.17	

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	*t*	*df*	*p*	Mean difference
2.568	0.0002*	2.337	42	0.024	0.489

*Equality of variances not assumed as Levene's test $p > 0.05$ (so, Welch *t*-test was considered).

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

Complications	No. of patients (%)
Thrombus	14 (33.33)
Postoperative edema	13 (30.95)
Infection	8 (19.04)
Ischemia owing to steal phenomenon	5 (11.9)
Aneurysm	2 (4.76)
Total	42 (100)

Discussion

In this study, the mean age of the patients with CRF was 46.5 (+13.5) years with median of 47 years. In the article by Mittal et al.,[7] the median age was 43 years (range 10 days to 90 years). As per Dash and Agarwal,[8] the mean age among the patients with CRF was 42.38 (±12.54) years, which is nearly consistent.[8] This study 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]

The patency rate was highest in radiocephalic type of AVF because 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, the mobilization and handling of the vessels is less, leading to lesser chances of edema and vessel wall damage. This in turn leads to better flow and 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. This finding may also be because of bigger diameter of the anastomosis itself. Anemia is a known factor that affects healing, in general. In our study, patients with anemia (Hb < 9 g %) showed less patency rate of fistula.

Among the complications found in this study, the most common complication was thrombosis (33.33%). 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 one study, 1.6%–8% of patients developed unilateral ischemia of the hand owing to steal syndrome,[15] while in our study, the incidence was 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° angle of anastomosis.[5]

In our study, infection accounted for 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 confounders in almost all researches across the globe. Ironically, in this study too, we could not find any reason 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. 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 the authors recommend future researches to study these factors. The authors have tried their 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 indicate 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 important to gain information about early clinical symptoms of AVF dysfunction to prevent and adequately treat potential complications.

We conclude from the study that AVFs created in younger age have better 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, steal phenomenon, edema, 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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