

Native arteriovenous fistula, surgical outcomes and primary failure in Taiz-Yemen: A prospective study

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Abstract:

Background: Haemodialysis (HD) is a lifesaving and life-sustaining management for patients with End Stage Renal Disease (ESRD). There are number of vascular access options including native Arteriovenous Fistulas (AVF), artificial arteriovenous grafts (AVG) and dialysis catheters. AVF is generally recognized as the cornerstone of long-term dialysis treatment due to its superior patency and lower complication rates. The present study investigates surgical outcomes and complications post AVF creation by Parachute Vascular Anastomosis Technique (PVAT) in Taiz, Yemen.

Materials and methods: This prospective study of 196 patients who underwent a native AVF created by parachute anastomosis technique from October 2017 to September 2019 in Authority of Althawra hospital in Taiz- Yemen. Detailed physical examination (inflow arterial pulses and outflow veins) was performed. Patients with abnormal physical examination were sending for preoperative sonography mapping. Non-dominant upper extremity was used as priority site for vascular access creation. AVF was performed under local anesthesia. Patients were followed up in outpatient clinic for six months.

Result: Total of 231 AVF in 196 patients, 121 (61.7%) were male and 75 (38.3%) were female. Mean age was 48.5 ± 16.8 (range 9–85) years. A majority of AVF were brachiocephalic 112 (48.5%) while the remaining was radiocephalic 74 (32%) and brachiobasilic 43 (18.6%). Most of patients had left non-dominant upper arm AVF. The immediate patency rate (palpable thrill intra operative) was 218(94.4%) with an overall functional rate (successful use of the AVF for six consecutive sessions of HD) of 198 (85.7%). The primary failure rate (within 3 months) was 33 (14.3%). Six months primary patency was 186 (80%). During study period, the most common complication of AVF was thrombosis 30 (13%).

Conclusion: Based in our result and literature review we could report excellent functional rate (85.7%) of AVF created by parachute vascular anastomosis technique. For that, parachute technique may be suggested as one of optimal selection to create AVF especially in elderly, diabetic patients.

Keywords: Haemodialysis access; Arteriovenous fistula; Parachute anastomosis technique; Primary failure

Introduction

Haemodialysis (HD) is a lifesaving and life-sustaining management for patients with ESRD, It is the most prevalent dialysis treatment modality and is identical to transplantation in terms of patient numbers, the latter modality considered to be is the preferred treatment for ESRD [1,2]. The optimal delivery of HD has been shown to result in improved patient outcomes. The success of HD mainly depends on the establishment of vascular access that is safe and reliable with minimal complication; which still a big challenge for vascular surgery as most hospitalizations, morbidity and mortality in those patients are due to impairment and complications of vascular access [3-5].

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There are number of vascular access options including native arteriovenous fistulas (AVF), artificial arteriovenous grafts (AVG) and dialysis catheters [6]. AVF is generally recognized as the cornerstone of long-term dialysis treatment due to its superior patency and lower complication rates [7]. Over last 50 years, AVF still represents the favorite vascular access to provide HD in terms of access patency [8], patient mortality [9,10], morbidity [11] and health cost [12] compared to other types. Kidney Disease Outcomes and Quality Initiative (KDOQI) guidelines recommend that 40% incident and 50% prevalent HD patients should undergo dialysis with an AVF [13].

AVF is created by a surgical anastomosis between native artery and vein, to allow access to vascular system for HD [14,15]. The preferred type of AVF is radiocephalic fistula which was the first AVF designed in 1966 by Brescia [16]. However, this access often fails to mature in the elderly patient with underlying vascular disease, particularly in diabetics [17]. Second preferred type is brachiocephalic fistula [18,19]. This type of fistula is being placed with increased frequency because of the high failure rate of radiocephalic fistula, followed by a brachio basilic transposition fistula [20].

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 evaluate risk factor that effect AVF patency and identify failure rate and post- operative complications that may occur after AVF placement [5].

To date, no publication has been reported on creating and outcomes of AVF in our city. Thus, Present study was conducted to identify functional, primary failure rate and complication of native AVF creation by (PVAT) in Taiz, Yemen from October 2017 to September 2019.

Patients and Methods

This prospectively study was conducted at Department of vascular surgery, Authority of Althawra Hospital in Taiz- Yemen, from 1st October 2017 to 30th September 2019. All patients with ESRD, who refer for creation AVF were include in this study. A total of 196 patients underwent 231 AVF operations were enrolled in the study. Details Demographic, Clinical, and preoperative dialysis variables were obtained for every patient. Allen's test and arterial pulses (i.e. axillary, brachial, radial, and ulnar) were examined. Patients with visible veins on the clinical examination were directly scheduled for AVF creation while patients with non-visible veins

were undergo vein mapping by ultrasonography (US) before being scheduled for surgery [21]. The distal part of the non-dominant extremity was selected as priority anatomical site, whenever possible [22]. All operations were created by the single Resident surgeon supervise by senior cardiovascular consultant.

Outcome parameter

Maturation (Functional) of AVF was be defined as the successful use of the AVF for six consecutive sessions of HD. This definition for the evaluation of AVF maturation has been validated in the literature in several previous studies [23-25]. Primary failure define as an AVF that has never been usable for dialysis or that fails within three months of use [26,27]. In our study, primary patency of AVF at immediate, 30 and 90 days, and at 6 months had been measured.

Procedure detail

AVF was routinely created under local anesthesia (2% xylocaine\3 mg/kg) or regional anesthesia and sedation for brachio basilic transposition anesthesia. Antibiotic did not give before the procedure. After cleansing and sterilizing the site of operation. A longitudinal incision (3 cm) made for the wrist or forearm region and a horizontal incision for the elbow antecubital region, the artery and vein are dissected and freed. Exposure of the vein was performed in a way to prevent its angulation and bending. At this stage, the distal part of the vein ligated. Heparinized isotonic saline pushed by syringe 20 cc with a feeding infant tube 6 fh for the proximal part of the vein then occluded via bulldog to block retrograde flow. After confirming vein suitability, the suitable artery suspended and arterial flow controlled with bulldog, small arterial branches were preserved. A longitudinal arteriotomy about 5-8 mm was performed in the forearm while a 4-6 mm performed in arm with surgical blade number 11 and Pott's scissors. The side underwent arteriotomy was suspended from both sides and an adequate view was achieved. End-to-side anastomosis by parachute vascular anastomosis techniques using 6/0 or 7/0 propylene sutures [28-31]. Anastomoses started from the opposite side (3 mm ahead of the middle of the posterior walls) of the artery. Suturing was continuous along the posterior vessel wall until extend beyond the arterial angle of anastomosis. At this time, both ends of the propylene suture were wet with heparinized saline and gentle pulling was applied, in a direction perpendicular to the axis of the both vessel walls to approximate "parachute" it together. Then the anterior vessel was suturing together with a continuation fashion until the anastomosis is finished at the same point at the beginning. After the last suture, both ends of the suture material were pulling gently, but putting the knot was delayed until the unclamping of

the radial or brachial artery. This permits the anastomosis site to become expanded to its widest size and prevents a purse-string effect at the anastomosis site. Thrill over fistula was confirmed, followed by adequate hemostasis before closure. The wound was closed in one layer using 3/0 absorbable mattress sutures for the skin with gentle antiseptic dressing was made.

Follow-up schedule

All patient discharges on operation day with oral antibiotics and analgesics for three days. Patients were instructed to start hand exercise on the second postoperative day with ball. Skin stitches were removed on the 10th post-operative day. The follow up performed on an outpatient basis, at 7th and 14th day then at 4 and 6 weeks post-operative, where fistula was released to puncture for HD. Periodic follow up was performed for at least 6 months (average 6 to 24 months). In follow up visit, all patients were be evaluated for the presence or absence thrill or complications i.e. seroma, hematoma, infection, bleeding, thrombosis, aneurysms, steal syndrome and venous hypertension.

Study analysis

Data collection and analysis conducted using SPSS (IBM SPSS Statistics 24.0). Initially, descriptive analysis of outcome and variables predominantly was analyzed as frequencies, tables and percentages for categorical variable and mean and SD for continuous variable. The association between variable and outcome or complication were analyzed by the Chi-square (x2) or fisher test for the categorical variable and unpaired Student’s t-test for the continuous variable with the corresponding 95% Confidence Interval (CI). P-values ≤ 0.05 were considered statistically significant.

Results

A total of 231 AVF procedures in 196 patients, 121(61.7%) were male and 77(38.3%) were female with male to female ratio of (1.5:1). The mean age was 48.5 ± 16.8 (range 9-85) years, majority (48.5%) of the patients belonged to age group 41–63 years; followed by (25.1%) patients belonging to 19–40 years of age.

Table 1 show that, functional rate of the fistula was highest 42/47 (89%) in the age group equal and more than 64 years followed by 97/112 (86.6%) in the age grouped 41–63 years. Function rates in other age groups were 48/58 (82.6%) in 19–40 years and 11/14 (78.6%) in <18 years. The function rates in male were 121/140 (86.4%) and 77/91 (84.6%) in female subjects, while the failure rates of AVF were 19/121 (13.6%) and 14/91 (15.4%) in male

and female subjects, respectively. However, this difference was statistically insignificant (p=0.7).

Table 1: Age and gender distribution of patients along with the function rate of AVF (n=231).

	Function, μ (%)	Failure, μ (%)	Total, μ (%)
Age groups			
<18	11(78.6)	3(21.4)	14(100)
19-40	48(82.6)	10(17.2)	58(100)
41-63	97(86.6)	15(13.4)	112(100)
64+	42(89.3)	5(10.7)	47 (100)
Gender			
Male	121(86.4)	19(13.6)	140(100)
Female	77(84.6)	14(15.4)	91(100)
Total	198(85.7)	33(14.3)	231(100)

Medical history of disease (Table 2) included hypertension in 146 (74%), diabetes in 53 (27%), CHD in 31 (15.8%) and PAD in 19 (9.7%) patients. In addition, patients with history of smoking and chewing Qat were 41 (20.9%), 15 (7.7%) respectively.

Table 2: History of disease and risk for patients undergoing hemodialysis.

History of Disease	Frequency	Percentage (%)
HTN	146	74.50%
Diabetes	53	27%
IHD	12	6.10%
CHF	31	15.80%
PAD	19	9.70%
CVA	12	6.10%
Smoking	41	20.90%
Chewing Qat	15	7.70%

Regarding the time of dialysis initiation majority of patients 180 (91.8%), were be referred late (after initiation or within 1 month). As in our finding, 144 (73.5%) patients had non-tunneled catheter at time of AVF creation. Furthermore, 175 (89.3%) patients have already had other forms of vascular access before AVF creation; one or more non-tunneled catheters were be used. Table 3 shows other pre-dialysis history of patients before AVF creation.

Table 3: Pervious dialysis history baseline character before AVF creation.

Dialysis history baseline items	Frequency (%)
Non-tunneled Dialysis catheters used/Number	
NO	21(10.7)
YES (Use one)	90(45.9)

Use tow	44(22.4)
Use three	19(9.7)
Use four or more	22(11.2)
Current catheter at time of operation	
NO	52(26.5)
YES	144(73.5)
Pervious AVF	
NO	123(62.8)
YES	73(37.2)
Previous procedures same limb	
No prior procedure	139(70.9)
One prior procedure	46(23.5)
Two prior procedures	11(5.6)
Dialysis at time of surgery	
NO	32(16.3)
YES	164(83.7)

In this study, all the patients had native AVFs with end-to-side anastomotic (parachute) technique. No grafts were used. Majority of patients 183 (79.2%) had left non-dominant arm. The most common AVF was the brachiocephalic 112 (48.5%), then radiocephalic 74 (32%), Brachiobasilic 43 (18.6%), one ulniobasalic AVF and on brachio-brachial AVF (Table 4). The first time cannulation were achieved after four, four to six and more than six weeks in 43 (18.6%), 134 (58%) and 28 (12.1%) patients respectively.

Table 4: AVF procedure (intra-operation) characteristics (n=231).

Baseline characteristics	Patient, μ (%)	Failure, μ (%)	Total, μ (%)	p-value
Access Side				
Left	157(68)	26(11.3)	183(79.3)	0.9
Right	41(17.7)	7(3)	48(20.8)	
Fistula Configuration				
Radiocephalic AVF	55(23.8)	19(8.3)	74(32)	0.016
Brachiocephalic AVF	99(42.9)	13(5.6)	112(48.5)	
Brachiobasilic AVF	42(18.2)	1(0.4)	43(18.6)	
Ulniobasalic AVF	1(0.4)	0	1(0.4)	
Brachio-brachial AVF	1(0.4)	0	1(0.4)	
TOTAL	198(85.7)	33(14.3)	231(100)	
Intraoperative Thrill				

YES	189(81.8)	18(7.8)	207(89.6)	0
NO	9(3.9)	15(6.6)	24(10.5)	
TOTAL	198(85.7)	33(14.3)	231(100)	
When Using Post Operation (weeks)				
< 4 wks	43(18.6)			
4 - 6 wks	134(58)			
> 6 wks	28(12.1)			

On assessing the patency of 231 fistulas, (n=198, 85.7%) fistulas were patent. Among this 198 patent fistulas, brachiocephalic fistula was 43%, followed by radiocephalic (23.8%) and Brachiobasilic fistulas (18.2%). We found that, the proximal fistula site (arm) and the present of good thrill intraoperative of AVF were significantly associated with a more favorable outcome of AVF Primary patency (P=0.016), (P=0.000) respectively. In our study, the primary patency rate was 203 (87.9%) at 1st month, 193(83.9%) at 3 months and 184(80.0%) at 6 months. Thirty- three (14.3%) fistulae failed within the first 3 months. Failing AVFs were managed by new fistula in our series. The most common complication was thrombosis 30 (13%) followed by noninfectious fluid collections (hematoma/seroma/lymphocele) 24 (10.4%), wound infection 17 (7.4%), bleeding 9 (3.9%) and Postoperative edema 10(4.3%). Aneurysm, venous hypertension and steal syndrome were found in 9 (3.9%), 4 (1.7%) and 3 (1.3%) cases respectively (Table 5).

Table 5: Post-operative Complications of AVF.

Complication	Frequency	%
Thrombosis	30	13%
Noninfectious fluid collections (hematoma/seroma/lymphocele)	24	10.40%
Infectious	17	7.40%
Limp edema	10	4.30%
Bleeding	9	3.90%
Infection and burst fistulae	7	3%
Aneurysmal degeneration	9	3.90%
Venous hypertension	4	1.70%
Steal syndrome	3	1.30%
Ischemic naturopathy	3	1.30%

Discussion

Effective formation and sufficient function of AVF in patients with ESRD need a multidisciplinary approach in determining and resolving the leading causes for primary failure. The process of AVF maturation is multifaceted and leftovers poorly understood, in spite of numerous studies describing the pathophysiology of the procedure and biomechanical issues associated with maturation. The Intimal Hyperplasia (IH) has been recognized as the highest

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pathohistological change, which arises in the blood vessels and was related with the primary failure of AVF [32]. However, the creation of AVF is the first step for the patients who need an efficient durable vascular access for HD.

The rate of primary failure of AV fistulas is highly variable and has ranged from 47 to 60 percent in randomized trials, but the published rates depend heavily on the definition of failure [33,34]. Mc Lafferty et al., described adequate AVF maturation of 82% and a primary failure rate of 18% in patients with AVF [35]. Monroy-Cuadros et al. noticed AVF failure in 81 patients out of 831 studied cases (rate=10%) [36], and Sari et al. reported 15.3% for incidence rates of primary AVF failure and never using AVF after operation [37].

Unsurprisingly, in a meta-analysis on 46 articles (7,393 AVFs), the generally risk of primary failure was 23%, but it enlarged in the elderly to 37% [38,39], and primary fistula patency was established in 26 of 43 patients (60%), meaning that AVF failure rate was equal to 40% [40]. In the previous years, a worse condition has been reported showing that from 101 fistulas only 47 fistulas (46.5%) established sufficiently to be used for HD, on behalf of the AVF failure rate of 53.5% [41]. Gjorgjievski et al., reported sufficient functioning was accomplished in 83.71%, and primary failure noticed in 16.29% of the created fistulae [42].

We define primary failure as an arteriovenous (AV) fistula that has never been usable for HD or that fails within three months of use [26,27]. In our study, adequate maturation was achieved in 85.7%, and primary failure occurred in 14.3% of the created fistulae. As discussed above, the rate of primary AVF failure in this study was similar or better compared to the average reported AVF failure rates in other parts of the world (Table 6).

Table 5: Post-operative Complications of AVF.

Reference	Publishing Year	Country/region	No. Patients/procedure	AVF Failure rate
Miller, et al.	1999	Birmingham, US	101	53.50%
Tordoir, et al.	2003	Netherlands	43	40%
Mc Lafferty, et al.	2007	Southern Illinois University, SIU	113	18%
Monroy-Cuadros, et al.	2010	Canada	831	10%
MacRae, et al.; Al-Jaishi, et al.	2014	London/UK	7393	23-37%
Dekhaya, et al.	2016	India	150	23.33%
Sari, et al.	2016	Turkey	36	15.30%
Gjorgjievski, et al.	2019	Macedonia	178	16.29%
Our Study	2020	Yemen	231	14.30%

The mean age of patients with ESRD undergoing AVF in our series was 48.3 years which was similar or close to other studies [43,44]. However, the mean age in developed countries was one or two decades older [25,38,42]. The influence of age on the patency of AVF is still controversial. Al-Jaishi et al., [38] and Gibson et al., [45] found that age had no effect on primary patency. The results in our study confirm that patient age is not a factor in the success of procedure and AVF should not be suspended from patients based on age similar observation was also found by other study [43,44,46,47].

We did not find a significant effect of gender on AVF patency in our study. In a literature review of 2012, Smith et al., 48 also found the same result. On the other hand, there're studies found significant differences in outcomes of AV fistula creation when comparing males and females [48-50]. In one study, females were at greater risk for failure of the AV fistula to mature compared with the males in spite of preoperative vascular mapping (hazard ratio 2.42, 95% CI 1.32-4.45) [51]. The reasons for these differences are not clear. It has been suggested that females have smaller vessels [45,52].

As has been alluded in many studies delayed presentation of ESRD patients to the hospital in developing countries and late referral for AVF creation have provided the need for temporary vascular access to have HD [53-55]. Early referral strategy significantly decrease morbidity [56], mortality [57,58], dialysis catheter insertion [59], urgent HD [60] and length of hospital stay [61]. In our study, majority of patients 180(91.8%) were referred late. We found that nine out of 10 patients in our series had a previous central venous access for emergency HD before referral for AVF creation. All this, adversely affect the available of suitable peripheral and central venous. So that, more proximal vein was used for AVF creation. This issues recognized clearly in our study, as about fifty present 105(46%) of our patients had their first native AVF creation in proximal upper limb veins. For that, numerous studies recommended the need for early referral and education for predialysis patients to prevent the use of peripheral (upper limb vein preservation strategy) and central venous catheters and to avoid their subsequent complications [35,62].

The left upper limb being the nondominant limb in most of the patients were used for the creation of AVF in the majority (79.3%) of our patients. The preference for the nondominant limb is as a result of the need to carry out minimal work or activities with the limb to preserve the delicate AVF, especially in the first two weeks following surgery. Similar preference for the non-dominant upper limb is also practiced in other study [43]. Brachiocephalic (48.5%) was the most common type AVF followed by radiocephalic type

(32%). Shan et al., [63] and Mc Lafferty et al., [35] found similar observation. In other hand many studies found radiocephalic most common [42,25].

AV fistula takes a number of weeks to mature, on average perhaps 4–6 weeks [64,65].

In our study, the first time cannulation were achieved after four, four to six and more than six weeks postoperative in 43(18.6%), 134(58%) and 28(12.1%) patients respectively. Surgical techniques are important factor that effect AVF patency [66]. Despite being variable in clinical applications, the end-to-side anastomosis technique is applied with 4 quadrant, 2-quadrant, oval, diamond-shaped or parachute techniques. There are reports of the common use of the standard parachute end-to-side anastomosis technique not only in Cardio vascular surgery, but also in many surgical fields including hepatobiliary surgery and gastrointestinal surgery [29-31,67]. The parachute technique may be an optimal selection in distal AVF where vascular structures are of lesser caliber, especially in DM, elderly patients, and diffuse vessel calcification [29,30,68,69]. In our study, all patients underwent end-to-side anastomosis (parachute) technique for AVF creation. With an immediate patency (palpable thrill intra operative) [46] was 218 (94.4%). In other study, immediate patency was 78%-90% [46,70,71].

Thrombus is the most common complication of AVF operations with a rate of 3-14.5% [16,44]. In our study, thrombosis was 13% of our patient. These figures were in agreement with the literature data. The most common cause of vascular access thrombosis is venous neointimal proliferation [72]. Similar finding was found [44]. Noninfectious fluid collections (hematoma/seroma/lymphocele) were 24(10.4%) all management simply by dressing and evacuation of fluid (Figures 1A-1C).



Figure 1A: Creation of anastomosis between a. radial and v. cephalic at the wrist site.



Figure 1B: Creation of anastomosis between a. brachial and v. cephalic at the antecubital fossa.

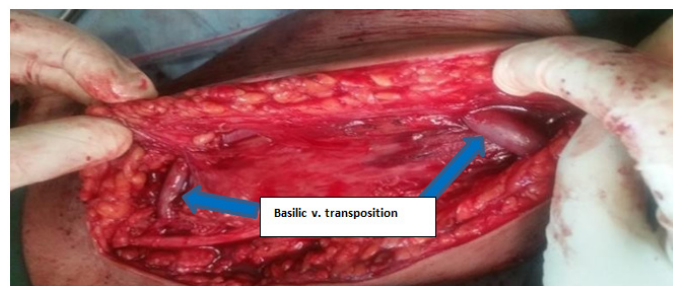


Figure 1C: Creation of anastomosis between brachial-basilic upper arm transposition.

In the studies by Dekhaiya et al. [44] and Schinstock et al. [5] infection was 8% and 26.8% respectively, while in our patients, Infection was found in 17 (7.4%), majority of these cases 10 (4.4%) management with observation (antibiotic) or aspirated and drainage. other seven (3%) infection progressive lead to burst fistulae, which management with emergency surgical intervention.

In the series, steal syndrome was observed in 1.6%-8.0% [5,44,73] while in our study this rate was 3(1.3%). History of diabetic disease was found statistically related to developed steal syndrome complication (p=0.002). However, female gender was not found to be statistically related to steal syndrome (p=0.33). Among these three cases, two cases were management by DRIL procedure, and one case by ligation with permanent tunneled catheters. Aneurysmal degeneration was found in 3.9% of our patients. While other studies it was observed in 2.0% to 8.5% cases [53,73]. Venous hypertension of arm was developed in four cases, we found statistically related between pervious central dialysis catheter used and venous hypertension (p=0.001).

Conclusion

Functional AVF is the gold standard for vascular access for hemodialysis. We report, excellent functional rate (85.7%) of AVF

created by parachute vascular anastomosis technique with primary failure rate (14.3%) compare to other study. For that, parachute technique may be suggested as one of optimal selection to create AVF especially in elderly, diabetic patients. The most common complication post AVF fistula was thrombosis 30 (13%), followed by noninfectious fluid collections 24 (10.4%), wound infections 17 (7.4%), bleeding 9 (3.9%), postoperative edema 10 (4.3%), aneurysmal degeneration 9 (3.9%), venous hypertension 4 (1.7%) and steal syndrome 3 (1.3%).

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