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Original Article

Comparing the outcomes of proximal radial artery arteriovenous fistula and brachio-cephalic arteriovenous fistula for hemodialysis vascular access

Hassan Kazemlou[1], Mohsen Khaleghian[2], Paniz Motaghi[3], Morteza Khavaninzadeh[4]

[1] MD, General Surgeon, Department of General Surgery, School of Medicine, Hazrat-e Rasool General Hospital, Iran University of Medical Sciences, Tehran, Iran

[2] MD, Assistant Professor of Vascular Surgery, Department of General Surgery, School of Medicine, Hazrat-e Rasool General Hospital, Iran University of Medical Sciences, Tehran, Iran

[3] MD, Research Manager, Department of General Surgery, School of Medicine, Hazrat-e Rasool General Hospital, Iran University of Medical Sciences, Tehran, Iran

[4] MD, Associate Professor of Vascular Surgery, Department of General Surgery, School of Medicine, Hasheminejad Kidney Center, Iran University of Medical Sciences, Tehran, Iran

Corresponding Author:
Tel: +98 912 137 3714
Email: mkhavanin@yahoo.com

Abstract

Introduction: Autogenous arteriovenous fistulas (AVFs) are the recommended type of vascular access for hemodialysis (HD). Nonetheless, the precise outcome of Proximal Radial Artery Arteriovenous (PRAAVF), as well as its risk of failure and complication, has yet to be determined.

Methods: In the current single-center, by retrospective analysis of prospectively collected data, we compared the outcome of Brachial Artery AVF (BAAVF) and Proximal Radial Artery Arteriovenous (PRAAVF) in end-stage renal disease (ESRD) patients who were referred to our center between 2010 to 2018. The outcome of the fistula was routinely assessed for all patients at least two years after the surgery. All data were analyzed in SPSS software (version 16). The success rate for each procedure was reported as a percentage. The Chi-square test was used to compare the success rate between the groups.

Results: A total of 146 patients (86 males, and 60 females) with a mean age of 55.79±17.03 years were included in the study. The results demonstrated that men and women did not significantly differ in the success rate of PRAAVF (P=0.076). The PRAAVF showed a significantly higher success rate in the 30-39 age range (P=0.03). The success rate of BCAVF did not display a significant difference between different age and gender groups (P> 0.05 for both). The success rate of PRAAVF was lower in both diabetic patients and smokers, as compared to that in healthy individuals (P=0.032 and P=0.001, respectively). None of the patients who underwent PRAAVF implementation had steal syndrome (as compared to the 2.8% rate of steal syndrome following BAAVF implementation)

Conclusion: As evidenced by the obtained results, PRAAVFs, which are associated with a very low risk of ischemic steal syndrome, can be regarded as safe and suitable vascular access. Accordingly, when it is anatomically feasible, PRAAVFs should be preferred over BAAVFs due to their superior clinical outcomes.

Keywords: Arteriovenous Fistula, Brachial Artery, Hemodialysis Access, Radial Artery, Vascular Patency

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Introduction

Due to an increase in the rate of end-stage renal failure patients and improved availability of hemodialysis (HD), many people undergo this treatment (1). The complications of HD vascular access are the most common cause of hospitalization in HD patients; therefore, it can be costly for health care providers (2-4). National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF KDOQI) and the Society for Vascular Surgery (SVS) both suggest autogenous arteriovenous fistulas (AVFs) for HD vascular access (5).

Although AVFs have a relatively high long-term patency, as compared to other types of HD access, they are not permanent (6). To increase the success rate and life span of AVFs, numerous studies have been implemented to determine the optimum site for the implementation of a fistula. In general, it is agreed that the justifiable approach is to start placing the fistula at distal veins with less diameter and preserve the proximal ones for later (1).

In addition, according to the NKF KDOQI guideline, distal radial artery-cephalic vein arteriovenous fistulas (DRCAVFs) at the wrist is the preferred configuration for the first HD access. In cases when the creation of DRCAVF is not feasible or the first trial has failed, the second suggested configuration would be an upper arm brachial artery-cephalic vein AVF, followed by the upper arm brachial artery-basilic vein AVF as the third choice. Arteriovenous grafts (AVGs) and tunneled central venous catheters (CVCs) are the last approaches (1). Multiple studies have questioned the success rate of DRCAVFs in females, obese patients, diabetic patients, and patients over the age of 65 (7).

Furthermore, looking from the thermodynamic perspective, a higher success rate and lower fistula maturation time can be achieved if the vein and artery have an identical diameter. According to recent evidence in this regard (8-9), we hypothesized a higher success rate, less maturation time, and less complication when the fistula is placed at the proximal section of the radial artery instead of its distal part. In addition, one of the concerns in HD patients is the occurrence of ischemic steal syndrome(ISS) which is expected to be lower in patients with Proximal Radial Artery Arteriovenous (PRAAVF). In light of the aforementioned issues, the present study aimed to compare the results of PRAAVF and Brachial Artery AVF (BAAVF) placements.

Materials and Methods

In the current study, patients who were admitted to the surgical department for the placement of AVF for HD access between 2010 and 2018 were retrospectively evaluated. This research was approved by the Ethics Committee of Iran University of Medical Sciences. (IR.IUMS.FMD.REC.1399.124).

all principles outlined in the Declaration of Helsinki were followed and given the retrospective nature an informed patient consent was not required.

A BAAVF was created according to the standard fashion after exposing both the appropriate vein and brachial artery to the antecubital crease, and an end-to-side anastomosis was then constructed. The PRAAVF configuration was placed through a longitudinal incision distal to the antecubital crease, and an end-to-side anastomosis was then constructed. For all patients, preoperative assessment and 2-year postoperative follow-up of fistula development, the patency of AVF, maturation time, and complications were conducted, and all findings were noted in patients' files.

Demographic data, social history, past medical history, drug history, past surgical history, cardiovascular comorbidities, as well as the outcomes and complications of all conducted surgeries for the placement of HD access, are routinely recorded at our center and these data were extracted for all patients from their files. We only included patients in the age range of 18-80 years old, those whose AVFs were created by using either the distal segment of the brachial artery or proximal segment of the radial artery, and patients who had previous surgery for fistula creation in this extremity. After the surgeries, all patients were under close observation. The duration of successful AVF use and the date it was abandoned was noted.

Any complications were recorded and taken into consideration. The presence of arm swelling,

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symptomatic ISS, and thrombosis, as well as the need for secondary surgical interventions, were recorded. Arm swelling was detected at physical examination, and hand elevation was recommended in cases with mild edema. The diagnosis of ISS was made according to physical examination findings suggesting hand ischemia (including coolness, pallor, mild paresthesia to paralysis, pain during dialysis or in more severe cases at rest, ulceration, and tissue necrosis) and confirmed by Doppler ultrasonography.

In this study, immediate failure (IF) refers to an AVF that has a loss of bruit or thrill within 72 hours after creation (3). A major complication was bleeding from the surgery site. Primary patency (intervention-free access survival) (PP) was defined as the interval between the time of access placement and any intervention designed to maintain or reestablish patency or to access thrombosis or the time of measurement of patency, while secondary patency (SP) represents the total lifespan from creation to access abandonment, end, or loss of follow-up (3). All data were analyzed in SPSS software (version 16). The success rate for each procedure is reported as a percentage. The Chi-square test was used to compare the success rate between groups.

Results

In the study period, 140 HD patients, including 58 females and 82 males, with a mean age of 56.1±16.8 years were enrolled, and the outcomes of their first fistula were evaluated. The mean follow-up time was reported as 26.4± .9 months. Among these patients, 8 (5.7%), 107 (76.4), and 87 (62.1%) cases had end-stage renal disorders, hypertension, and diabetes, respectively. Moreover, 15 patients were smokers. In 32 (22.9%) patients, AVFs were placed on the proximal radial artery, and in the remaining 108 (77.1%) cases, AVFs were implemented on the brachial artery. Demographic data are summarized in Table1.

Table 1. Demographic variables in the study population

Demographic variable	Total	PRAAVF	BAAVF Number (percentage)	P-value of difference between two groups
Gender (male: female)	(82:58)	(18:14)	(64:44)	0.38
Age	56.1 ±16.8	56.6±16.6	56 ±16.9	0.31
BMI	26.3 ±5.3	26.2±5.1	26.3 ±5.3	0.46
Smoking	21 (15)	5 (15.6)	16 (14.8)	0.45
Hypertension	104 (74.3)	25 (78.1)	79 (73.1)	0.28
Diabetes mellitus	59 (42.1)	14 (43.8)	45 (41.7)	0.42
Cardiac morbidities	23 (16.4)	4 (12.5)	19 (17.6)	0.25

The overall success rate in patients who had PRAAVF was 93.9%. No case of ISS was reported. In the other group, who had BAAVF, the success rate was obtained at 82.2%. (P=0.05) In 3 (2.8%) patients, ISS occurred. Outcome measures are summarized in Table2.

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Table 2. Outcome measures in patients who underwent AVF construction

Variable	PRAAVF	BAAAVF	P-value
Total number	32 (22.9%)	108 (77.1%)	-
Mean time to prepare for dialysis (time to maturation)	40 days	42 days	0.62
Primary success rate	93.9%	82.2%	0.05
Postoperative Complications:			
Steal syndrome	0 (0%)	3(2.8%)	0.34
Pseudoaneurysm	1(3.1%)	4(3.7%)	0.88
Swelling Arm	2 (6.3%)	11(10.2%)	0.50
Infection	1(6.3%)	9(7.4%)	0.16

|The Chi-square test was used to evaluate the relationship between the success rate of PRAAVF, compared to BAAVF between males and females. The results demonstrated that there was no statistically significant difference in success rates between men and women (P=0.076). The results of the Chi-square test suggested that the success rate of the proximal radial artery to an appropriate vein fistula, compared to brachial artery fistula, was significantly better in the age group of 30-39 years, as compared to that in the older population (P=0.03). In patients with a history of diabetes and smoking, the success rate of PRAAVF, compared to BAAVF, was lower than that in healthy individuals (P=0.032 and P=0.001, respectively). In people with diabetes mellitus, this difference was significant in women but not significant in men (P<0.001). In patients with other underlying conditions, no significant difference was observed in the success rate of PAAVF with BAAVF. In patients who underwent PRAAVF placement, no special complication was reported, as compared to the BAAVF group with three reported cases of ISS. No statistically significant difference was observed in outcome measures (Table2).

Discussion

In comparison with prosthetic grafts and central venous catheters, AVFs are the preferred type of vascular access for patients needing hemodialysis since they have a reduced infection risk, as well as lower morbidity and mortality. Moreover, AVFs are associated with low thrombosis and infection rates, fewer hospital admissions for access revision, and lower healthcare-related costs(10). An acceptable and effective vascular access for chronic HD should have a long-term patency rate, low complication rate, and good acceptance by the patient (11).

The NFK/DOQI has developed a guideline for surgeons to make a decision about the order of preference for vascular access. The approach is to place AV accesses as far distally in the upper extremity as possible to preserve proximal sites for the future. Their first suggestion is DRCAVF at the wrist, followed by a BAAVF in the upper arm. The third suggestion is a transposed brachial artery-basilic vein AVF or an AVG. The NFK/DOQI does not encourage catheter placement as permanent vascular accesses (3-12).

In recent studies, the creation of AVF at the wrist was found to be associated with a higher risk of failure. Moreover, difficulty in maintaining the patency of wrist AVFs seems to increase in older patients, diabetic patients, patients with a history of catheters, as well as patients with peripheral vascular diseases and poor quality of distal veins(13-15). On the other hand, BAAVFs have a higher risk of steal syndrome,

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arm ischemia, high-output heart failure, and right ventricular dysfunction, as compared to wrist fistula. Severe ischemia due to AV fistula, which requires immediate intervention, occurs mainly in patients who have distal forearm AVF (about 1% of patients) and AVFs originating from the brachial artery (about 3%-6% of patients) (6-16).

One safe and feasible alternative for BAAVFs can be a fistula created in the proximal forearm involving the proximal segment of the radial artery. The PRAAVFs were first introduced by Toledo-Pereyra et al. (18). The first experiments were carried out by connecting the proximal radial artery to the cephalic vein and yielded promising results. Despite many advances in this regard, PRAAVFs have not attracted many surgeons till now (19). In a systemic literature review published in 2015, 10 articles (1,310 patients) on the outcome of PRAAVF were reviewed.

According to their findings, the primary failure rate was 12.3% which is more than that obtained in the current study. They concluded that PRAAVF is a safe and reliable choice when the creation of DRCAVF is not feasible or has been unsuccessful. On the other hand, PRAAVF has not gained popularity and is not included in the NFK/DOQI preference list for HD vascular access.

In addition, selection criteria for the placement of AVF on this site are not clear and a variety of veins are used by surgeons (20).

Kumar et al. conducted a retrospective study on 320 patients to evaluate the outcome of patients who had radio-median cubital vein/radiocephalic fistula at the elbow, with a focus on the rate of steal syndrome. They concluded that these techniques are safer than BAAVFs since BAAVF leads to the dilatation of only the cephalic vein, while the introduced techniques lead to the dilatation of both cephalic and basilic veins; therefore, they do not cause vascular steal syndrome in their experience. In this study, patency and flow rates were similar to BAAVFs (11).

In a similar vein, Morris et al. (2001) reported that the risk of ISS is extremely rare after radio-median cubital vein/radiocephalic fistula at the elbow (which was 0% in our series), as compared to 20% with BAAVFs (21).

The safety of PRAAVFs can be attributed to the fact that the diameter of the proximal segment of the radial artery and adjacent segment of the cephalic vein are roughly identical. The less difference between the diameter of the artery and vein is one of the predicting factors for the maturation time of the fistula (22-23). Among the major limitations of this study, we can refer to the unequal number of patients in groups. Although we achieved less proportion of pseudoaneurysm, arm swelling, ISS, and infection in the PRAAVF, the differences were not statistically significant, which can be ascribed to small sample size and inequality of group sizes. Furthermore, we did not consider the reason for access failure (such as thrombosis or low flow) when comparing the result of the groups. It is suggested that randomized clinical trials be conducted in the future.

Conclusion

The PRAAVFs, which are associated with a very low risk of ischemic steal syndrome, can be regarded as safe and suitable vascular access. As evidenced by the results of this study, the diameter difference between the artery and vein is the major predictor of AVF success rate. Accordingly, when it is anatomically feasible, PRAAVFs should be preferred over BAAVFs due to their superior clinical outcomes. It is recommended that surgeons create PRAAVFs through a longitudinal incision and then make an end-to-side anastomosis to achieve a better outcome.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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