Perforating Vein-Brachial Artery Anastomosis as an Alternative to the Conventional Arterio-Venous Fistulae for Haemodialysis: Mid-Term Follow-up Results

Hemodiyaliz Amacıyla Oluşturulan Konvansiyonel Arteriyo-Venöz Fistüllere Alternatif Olan Perforan Ven-Brakiyal Arter Anastomozu: Orta Dönem Sonuçlar

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Geliş Tarihi/*Received:* 03.04.2010
Kabul Tarihi/*Accepted:* 07.06.2010

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ABSTRACT Objective: We sought to determine the usefulness of the brachial artery to perforating vein anastomosis created for haemodialysis by evaluating cardiac performance, patency rate of and maturation time to arterio-venous fistula (AVF), reintervention need and morbidity of the procedure. **Material and Methods:** Thirty two end stage renal disease patients in whom previous radio-cephalic anastomosis had failed or radial artery and cephalic vein were not suitable for an anastomosis were prospectively included in this study. In the postoperative period, cardiac performance, patency rate, maturation time, and morbidity were evaluated. **Results:** The median follow-up time was 14 (12-22) months. Twenty seven patients (27/32, 84%) successfully developed maturity at the end of the follow-up period. The median time for maturation of AVF was 3,4 weeks. Primary and secondary patency rates were 68% (22/32) and 84% (27/32) respectively. Ten patients required reintervention. In 5 patients patency was achieved through thrombectomy. In 5 patients reintervention was not successful to maintain haemodialysis. Two patients with findings of venous hypertension were treated conservatively. Ischemic findings or steal phenomenon were not observed. Ejection fraction, stroke volume and cardiac output have increased. Nonetheless, high output cardiac failure was not recorded. **Conclusion:** In patients with an unfunctional wrist fistula or those in which a wrist fistula is not possible to form due to vascular structure, the perforating vein to brachial artery anastomosis at elbow level is a reasonable preference due to high patency rate, early maturation time, lower complication rate, and favorable hemodynamic effects.

Key Words: Arteriovenous fistula; vascular patency

ÖZET Amaç: Hemodiyaliz amacıyla brakiyal arter-perforan ven anastomozunun etkinliğinin değerlendirilmesi ve olgunlaşma zamanının, açık kalma oranlarının, girişim gerekliliğinin ve işleme ait morbiditenin belirlenmesidir. **Gereç ve Yöntemler:** Daha önce radio-sefalik arteriyo-venöz fistül (AVF) açılan ve başarısız olunan ya da radiyal arter veya sefalik venin anastomoz için uygun olmadığı 32 hasta prospektif olarak değerlendirildi.Postoperatif periyodda açık kalma oranı, olgunlaşma zamanı, kardiyak performans üzerine etkileri ve morbidite değerlendirildi. **Bulgular:** Ortalama 14 (12-22) haftalık takip süresinde %84 (27/32) hastada AVF başarılı bir şekilde ortalama 3.4 haftalık bir sürede olgunlaştı. Primer ve sekonder açık kalma oranları sırasıyla %68(22/32) ve %84 (27/32) idi. Beş hastada açık kalma trombektomi ile sağlandı. Venöz hipertansiyon gelişen2 hasta konservatif yöntemler ile tedavi edilirken hiçbir hastamızda arteriyel iskemi bulgusu gelişmedi. Ejeksiyon fraksiyonu, kardiyak output ve strok volüm artmış olmasına rağmen yüksek debili kalp yetmezliği tespit edilmedi. **Sonuç:** Brakiyal arter-perforan ven anastomozu; uygunsuz damar yapısı nedeni ile açılamayan ya da fonksiyonel olmayan el bileği bölgesindeki fistüller için, yüksek açık kalma oranları, erken olgunlaşma zamanı, düşük komplikasyon ve olumlu hemodinamik etkilerinden ötürü iyi bir alternatiftir.

Anahtar Kelimeler: Arteriyovenöz fistül; damar açıkkalımı

Turkiye Klinikleri J Cardiovasc Sci 2010;22(2):200-5

Recently, life expectancy of patients with end stage renal disease (ESRD) has prolonged with increased experiences in haemodialysis. Substantial developments in the field of renal transplantation surgery also increased life expectancy; however limited number of donors is the major challenge. Therefore, continue hemodialysis is still a life style for these patients and the need for creation of arteriovenous fistulas (AVF) persists. AVF's are expected to have a long patency rate without complication. Many patients require more than one fistula in their life time. Thus, an AVF should be created by the principle of periphery to centrum. In many patients radio-cephalic AVF is the first choice due to its low complication rate and easy accessibility.[1] However, in patients with ESRD, distal cephalic veins frequently have a poor flow and radial artery can be calcific.[2-5] In such cases, new methods easy to perform with low complication rates and high patency rates are required. The secondary vascular access procedure of choice is the formation of an autogeneous (native) vein AVF at the elbow.[6] The proximal forearm antecubital fistula described by Gracz[7] is a valuable option for maintenance haemodialysis in patients with damaged veins at the wrist or advanced atherosclerotic and calcified radial arteries. Some modifications of Gracz fistula were made by Bender et al,[8] and Konner et al[9] by creating a side-to-side anastomosis between brachial artery and medial antecubital vein with or without ligation of the perforating branch respectively. Recently, promising results have been demonstrated in elbow fistulas by creating a radial artery-perforating vein[10] and brachial artery-median antecubital vein anastomosis.[11] Ligation of the perforating vein can also be added to this operation.[12] However, efficacy of a perforating vein to brachial artery fistula needs to be proven. Thus, we have evaluated the usefulness and safety of the perforating vein to brachial artery anastomosis and discussed the early and late results of this procedure.

MATERIAL AND METHODS

Thirty two patients who required AVFs for continue haemodialysis were included in this study. Twenty four patients had failed radio-cephalic fistulas. In eight patients, brachial artery-perforating vein anastomosis was the first choice because of the unsuitability of radial artery and/or cephalic vein for an anastomosis. Characteristics of the patients such as age, gender, history of tobacco use and medical history are presented in Table 1. None of the patients received exogenous erythropoetin during the study period. Echocardiography was performed prior to and 6 weeks after the creation of the arteriovenous access (Table 2). M-mode measurements were performed for the following parameters: left ventricular end diastolic and end systolic diameters, shortening fraction, left atrial dimension, interventricular septal end diastolic and end systolic diameter, left ventricular posterior wall end diastolic and end systolic diameter. The following parameters were calculated using

TABLE 1: Baseline characteristics of the study patients.

Age (years)	58.4 ± 16.7
Gender (male/female)	18 / 14
Diabetes mellitus (n, %)	25 (78%)
Hypertension	28 (87%)
Smoking	10 (31%)
Peripheral artery disease	8 (25%)
Coronary artery disease	10 (31%)
Serum creatinine level (mg/dL)	8.67 ± 3.74
Hemoglobin level (g/dL)	10.0 ± 1.88

TABLE 2: Echocardiographic findings before and after a-v access operation.

	Before	After	P
Stroke volume (mL)	74.8 ± 6.8	88.2 ± 8.0	0.015
Ejection fraction (%)	60.8 ± 5.0	66.2 ± 6.3	0.028
Shortening fraction (%)	33.2 ± 3.5	37.6 ± 4.0	0.024
Cardiac output (L/dk)	5.26 ± 0.95	6.62 ± 1.32	< 0.001
LVEDD (mm)	50.2 ± 3.5	54.4 ± 4.2	0.045
LVESD* (mm)	34.8 ± 3.1	35.1 ± 2.9	NS
IVS thickness* (mm)	12.5 ± 1.8	13.0 ± 1.6	NS
Posteriyor wall thickness* (mm)	12.0 ± 1.5	12.4 ± 1.9	NS

LVEDD-LVESD: Left venticular end-diastolic and end-systolic diameters
IVS: Interventricular septum, * these parameters did not changed significantly (p> 0.05)
t-test for paired samples was used for statistical analyses.

Teicholtz method: end diastolic and end systolic volume, stroke volume, ejection fraction, cardiac output and cardiac index. Echocardiograms were performed using GE-Vivid 4 cardiovascular ultrasound equipments.

Maturation time was defined as the interval between creation of the fistula and its functional use for haemodialysis. Function was defined as the ability to perform haemodialysis with an adequate blood flow in at least five consecutive dialysis sessions. Primary patency was defined as the patency in the interval between the initial operation and either fistula failure or need for reintervention. In this interval, the patients could undergo haemodialysis using the fistula effectively. Secondary patency was described as the patency after any reintervention in addition to the primary patency. Reinterventions were defined as thrombectomy, balloon fistuloplasty and drainage of hematoma. Venous hypertension was described as the presence of swelling in hand or fingers, their limited motility or development of venous gangrene. Arterial ischemia was defined as the presence of cramping with exercise, poorly palpable radial artery or pain requiring surgical revision.

FIGURE 1: The venous anatomy of the elbow before the anastomosis (BA: brachial artery, PV: perforating vein).

FIGURE 2: Brachial artery to perforating vein anastomosis.

OPERATIVE PROCEDURE

In all patients, native arteriovenous fistulas were created. Whenever possible, the nondominant arm was chosen for the procedure. If the patient had a previously placed dual lumen catheter in one arm, the contralateral arm was used. Operating loupe (magnification: 2.5X) was used by the surgeons in all cases. The procedures were performed under local anesthesia. In all patients, transverse incision about 3 cm long 1 cm distal to antecubital crease was made to expose brachial artery and the confluence of the basilic vein, cephalic vein and perforating vein. The perforating vein located at the junction of the cephalic and basilic vein was disconnected from the distal tip of the vein and anastomosed to the brachial artery (Figure 1-2). Anastomoses were created by end to side technique using 6/0 or 7/0 polypropylen sutures depending on the vessel size. The surgical complications in the peroperative and postoperative periods were analyzed. In the postoperative period, heparin was given for 24 hours in all patients to prevent for thrombotic events. Until maturation was achieved, patients were recommended to exercise their hands. In the mean time the need for dialysis was fulfilled by a double-lumen central venous catheter inserted in internal jugular vein or subclavian vein. During the follow-up, the patency of the fistula was assessed either by palpation for a thrill, auscultation for a bruit, or when necessary by using a handheld Doppler device.

RESULTS

Thirty-two patients aged 24 to 72 years (mean 58 ± 16) were evaluated. The epidemiologic findings of

the patients are summarized in Table I. In the short-term follow-up, comparison of the preoperative and postoperative echocardiographic findings of the patients revealed that cardiac hemodynamics were increased. This is probably due to the increased venous return caused by the AVF (Table 2). Nevertheless, this procedure did not lead to high output cardiac failure.

The median follow-up time was 14 (12-22) months. Twenty seven (27/32, 84%) patients completed their maturation successfully at the end of the follow-up period. The median time for maturation of the AVF was 3, 4 weeks. Primary patency rate was 68% (22/32). In the remaining 10 patients the fistula failure was thought to be caused by thromboembolism. Therefore thrombectomy was employed as a reintervention in all 10 patients. In 5 of these thrombectomy was successful. Under the antiaggregant therapy, thrombosis did not recur and the patients could undergo haemodialysis through their fistulas effectively. In the remaining 5 patients reintervention was not successful to maintain haemodialysis. The underlying etiology in two of these patients was venographically shown to be secondary to subclavian vein stenosis and mechanical compression of the axillary vein. Angioplasty was considered to overcome the stenosis in these patient and. we have referred them to another centers. However, in one patient angioplasty was not successful, and we could not contact with another one. No arterial ischemia or steal syndrome was observed. The patients were also followed up for paresthesia, throbbing pain, cramping with exercise, swelling in the hand or fingers or venous gangrene. In two patients, swelling in the hand developed and was treated conservatively. None of the patients had major bleeding or wound site infection. In two elderly patients with diabetes mellitus hyperemia around the incision was observed but it resolved spontaneously.

DISCUSSION

In this paper, we have demonstrated the usefulness and safety of the perforating vein to brachial artery anastomosis in patients diagnosed with end stage renal disease.

The life expectancy of the patients undergoing hemodialysis continues to extend, as a result, many patients with end stage renal disease undergo multiple haemodialysis access procedures. Furthermore, patients with end stage renal disease undergo multiple forearm vein punctures for the diagnostic blood analyses. These lead to a difficulty in finding a forearm vein appropriate for an anastomosis in consequent AVF operations. A mature and well-functioning AVF is crucial in ESRD patients. According to the latest literature, a significant number of AVFs (28% to 53%) never become mature to perform haemodialysis.[13] Especially, wrist fistulas (Brescia-Cimino) have been shown to have particularly high failure rates.[14,15] In a recent meta-analysis the weighted mean of 1- year and 2- years primary success rates of distal radial to cephalic vein fistulas have been reported as 57% and 45% for the patients younger than 65 years of age.[16]

In recent trials using elbow fistulas, Weyde et al,[10] reported that primary patency rate for radial artery-perforating vein fistula was 47% after 1 year, 43% after 2 years and 39% after 3 years. Consequently, Moini et al[12] declared that the primary patency rates were 89.7% and 83.7% at 1 and 2 years respectively. In our study overall primary patency rate of 68% is achieved which is a comparable ratio to those in other studies. Therefore this technique seems to be a reliable method for creation of AVF. Chin et al[11] have reported that all upper arm fistulae included brachial artery to cephalic vein (n= 27), brachial artery to basilic vein (n= 13), and brachial artery to median antecubital vein (n= 13) provide sufficient inta-access blood flow. In that study, they have considered only 9 patients with a brachial artery to perforating vein fistula. They have noticed that overall blood flow is enough in this type of fistula. Our study has included 32 patients all with a brachial artery to perforating vein fistula, and provided a high patency rate, with early maturation time, lower complication rate, and favorable hemodynamic effects.

A part of literature regarding AVFs focuses on development of venous hypertension.[17] Bachleda et

al reported that the venous hypertension depends on anatomy of the subcutaneous venous system as well as on the type of the surgical method.[18] In our study, we have observed the finding of venous hypertension in only two patients. This favorable result is probably achieved because of the disconnection of deep and superficial venous systems by this technique. We have not observed any critical arterial ischemia either. A possible explanation for this could be that, perforating vein used for the anastomosis had restricted the flow passing through brachial artery to cephalic and basilic veins, as shown in Blalock-Tausing shunt operations. Supporting this, Gracz et al. proposed that when a proximal forearm AVF is created, it is necessary to use the perforating vein as well.[7]

It has been hypothesized that, in Gracz type fistulas, incidence of steal phenomenon could be lower compared to other types of upper-arm fistulas since the smaller caliber of the perforating vein may serve as a natural "throttle" limiting the excess blood flow.[12] Our study supported this opinion. In addition to this, we have demonstrated that this type of fistula has supplied sufficient blood flow to increase cardiac output. During the follow-up, high output cardiac failure has not been detected. Hence, we can conclude that this technique does not have unfavorable hemodynamic effects. The most important advantage of this technique is that, this anastomosis provides a fistula with a dual venous outflow meaning that hemodialysis is accomplished by both of cephalic and basilic veins; this in turn, makes the durability of the AVF longer compared to other techniques.

A limitation of our study was that we have not used a control group consisting of patients with "classical" wrist fistulas. In the current literature, however, there are already sufficient data regarding conventional wrist fistula patency rates. In this observational study, our primary aim was to evaluate the efficacy and safety of this type of fistula in patients with failed previous fistulas or inappropriate wrist vessel anatomy. Additionally, a longer follow-up time could render more important knowledge regarding this technique.

In a conclusion, in the patients with an inappropriate wrist vasculature or failed previous radio-cephalic fistula, creation of an elbow fistula between the brachial artery and perforating vein seems to be a safe and effective procedure.

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