

# The Effect of the Keyhole Technique on Diabetic Patients Undergoing Autologous Brachiobasilic Transposition of an Arteriovenous Fistula

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## ABSTRACT

**Purpose.** Our aim was to investigate the efficiency of the keyhole transposed brachiobasilic technique in patients with diabetes mellitus and compare the effect of different arteriovenous fistula techniques on the development of complications.

**Materials and Methods.** Thirty-eight diabetic, chronic renal failure patients (group 1) had transposed brachiobasilic arteriovenous fistula creations, and 49 diabetic patients (group 2) had other types of fistula creations and histories of multiple fistula attempts. The 2 groups were compared for age, sex, weight, the presence of hypertension and/or diabetes mellitus, other risk factors, arteriovenous fistula patency, and possible complications.

**Results.** The 2 groups were not different statistically regarding the demographic data including age, sex, weight, the presence of hypertension and/or diabetes mellitus, other risk factors, and mean operation time. The median follow-up after surgery in both groups was 8 months. The primary patency in group 1 was 97.4% in the early period (6 weeks after surgery) and 94.7% in the late period (mean duration of 8 months after surgery). In the second group, these rates were 73% and 62%, respectively ( $P < .05$ ). The secondary patency rates were 84.2% in group 1 and 53% in group 2 ( $P < .05$ ). In group 2, the primary and secondary patencies of brachiocephalic and radiocephalic fistulas were significantly lower than the patencies of group 1. The incidence of complications was significantly less in group 1 than in group 2 ( $P < .05$ ).

**Conclusion.** Although the groups were small in size, the success rate with the keyhole transposed brachiobasilic technique in patients with diabetes was extremely gratifying, and this report can be considered to document the first attempt of a hemodialysis-access procedure.

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## INTRODUCTION

Patients with diabetes mellitus who require chronic hemodialysis access usually require multiple attempts and different techniques for arteriovenous fistula (AVF) creation and have decreased long-term patency rates. The fistula of Brescia and colleagues [Brescia 1966] is usually the first choice for patients who start hemodialysis. Radiocephalic AVF (RCAVF) is the procedure of choice (Figure 1). However, a number of patients lack a suitable vein in the forearm. Upper-arm brachiocephalic fistulas (BCAVFs) have been reported as secondary procedures after failure of the distal sites (Figure 2). The effect of diabetes mellitus on maturation and patency of AVFs has been investigated rarely in the literature [Hakaim 1998]. In the study by Hakaim et al, both primary BCAVFs and transposed basilica vein AVFs (TBAVFs) (Figure 3) demonstrate significantly greater maturation and increased primary cumulative patency rates than RCAVFs. BCAVF was first reported as a primary access procedure in studies with occluded radial arteries; however, a history of diabetes was not documented [Cascardo 1970; Hakaim 1998]. The patients with diabetes mellitus have a greater tendency to have prolonged wound healing [Jaar 2000]. Infected dialysis access or an infected foot, impaired cellular and humoral immunity, and nutritional deficiency may play major roles [Vanholder 1993]. This pathophysiologic finding usually affects the wound site in patients with vascular access. The surgical technique for basilica vein transposition requires a large incision with excessive vein dissection that may result in postoperative wound infection, skin necrosis, lymphatic leakage, and nerve injury. An incidence rate of 2% to 5% for postoperative wound infections and lymphatic problems has been reported for this method [Humphries 1999]. The long incisions that are made during RCAVF, BCAVF, and TBAVF procedures may have an impact on the maturation and diminished short- and middle-term patencies of these AVFs [Ascher 2001]. The reasons for nonmaturation of RCAVFs in patients with diabetes remains to be defined [Hakaim 1998]. The surgical technique for the creation of a BCAVF was first described by Dagher et al and it involves the transposition of the basilica vein from deep subcutaneous tissues to a more superficial location along the volar surface of the upper arm [Dagher 1976]. This procedure

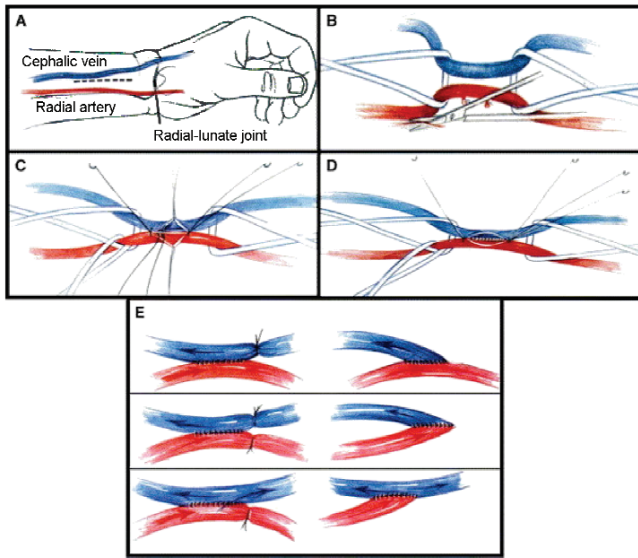


Figure 1. Creation of a radiocephalic arteriovenous fistula (Brescia-Cimino). A and B, Dissection and isolation of the radial artery and cephalic vein at the wrist. C and D, Creation of a side-to-side anastomosis. E, Various techniques for tying off the distal vein to create a functional end-to-side anastomosis. Reprinted from *Cardiology Clinics*, Volume 23. Roy-Chaudhury P, Kelly BS, Mehlem M, et al. Vascular access in hemodialysis: issues, management and emerging concepts. 249-73. Copyright 2005, with permission from Elsevier. (Courtesy of Dr. Michael J. Hanaway, University of Cincinnati, Cincinnati, OH, USA.)

requires extensive mobilization of the vein. The keyhole technique for BCAVF has been developed to prevent these long incisions. The procedure involves the use of small incisions 2 cm long under local anesthesia (Figure 4) [Hill 2005].

We sought to demonstrate the effect of the keyhole technique on early-term (after 6 weeks) and late-term (after 8 months) patencies as well as on the risk of developing complications. We recorded complications such as wound healing and risk of infection and compared the results with previous AVFs that were formed using different types of long incisions.

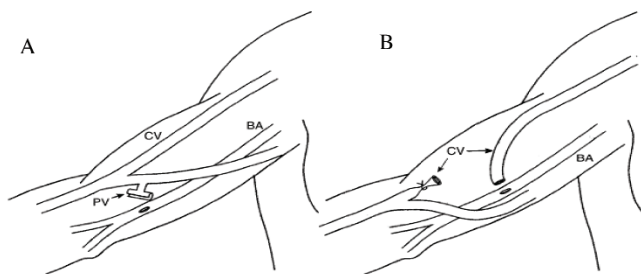


Figure 2. A, Brachial-cubital arteriovenous fistula (Gracz). B, Brachial-cephalic arteriovenous fistula. BA indicates brachial artery; PV, perforating vein; CV, cephalic vein.

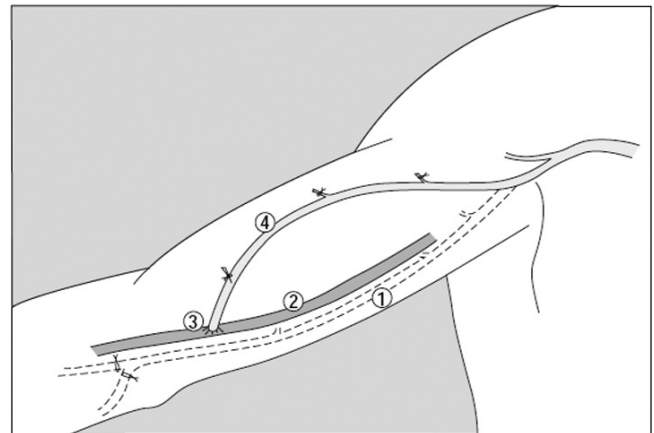


Figure 3. Transposition of basilica vein for arteriovenous fistula. 1 indicates basilic vein beneath deep fascia; 2, brachial artery; 3, arteriovenous end-to-side anastomosis; 4, basilic vein transposed to subcutaneous position. From: Butterworth PC, Doughman TM, Wheatley TJ, Nicholson ML. 1998. Arteriovenous fistula using transposed basilic vein. *Br J Surg* 85:653-4. Copyright British Journal of Surgery Society Ltd. Reproduced with Permission. Permission is granted by John Wiley & Sons Ltd on behalf of BJSS Ltd.

## MATERIALS AND METHODS

Between January 2003 and December 2005, 87 AVF operations were performed on chronic renal failure patients with diabetes at the Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital in Istanbul, Turkey. The data were reviewed retrospectively from the computer system records and charts. Keyhole brachiobasilic vein transposition was performed in 38 patients (group 1) who had a history of diabetes mellitus and previous multiple AVFs. The other 49 patients (group 2), who were also diagnosed with diabetes mellitus and had had previous multiple AVFs, underwent different AVF procedures. The distribution of different AVF procedures performed on each group of patients is shown in Table 1. The demographic data that were evaluated included age, sex, weight, the presence of hypertension and/or diabetes mellitus, cardiovascular disease, smoking, previous vascular access, the use of medications such as aspirin, warfarin, or erythropoietin, mean operation time, primary and secondary AVF patency, and mean duration of follow-up (Table 2). Complications including arm edema, thrombosis, stenosis, venous bleeding, wound infection, lymphatic leakage, arterial steal syndrome through the AVF, and nerve injury are shown in Table 3. Prior to the procedure, patients had their nondominant arm identified and selected for the operation. The vein used was determined by physical examination with tourniquet compression. The dominant arm was used in 3 patients: in one patient it was selected because of an aneurysm in the nondominant arm, and in 2 patients because of an occluded graft. The antibiotic prophylaxis included 500 mg of vancomycin in diabetic patients; for the others, 500 mg of cephazolin (one dose) was given intravenously. The procedure was conducted under local

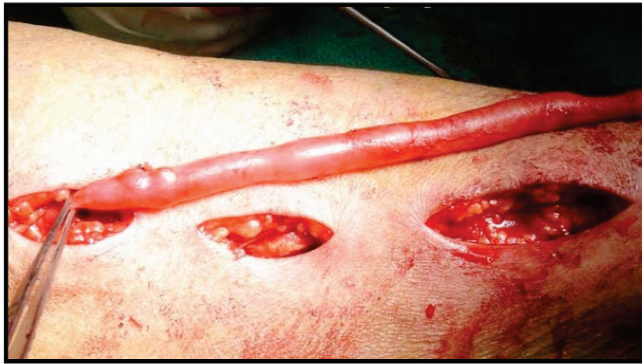


Figure 4. The preparation of the basilica vein.

anesthesia of the axillary block, with marcaine 0.25% 15 cc and saline solution of 15 cc administered with a gauge 22 needle, and sedation with midazolam (0.05-0.07 mg/kg).

The technique for brachio basilic vein transposition involves exposure and division of the basilica vein at the elbow. The first incision was at the antecubital fossa, 1 to 2 cm distal and medial to the fossa. The basilica vein was found and dissected from the surrounding tissue. Using the tunneling technique that involves 2 or 3 2-cm incisions until reaching the axillary region, 2 or 3 keyholes were made (Figure 4). The guide that was introduced into the vein included 0.035-inch thick, 180-cm long Glidewire (Terumo, Ann Arbor, MI, USA), and the tip was advanced to the junction at the superior vena cava and the right atrial junction. A 6F vein extractor catheter (Grove Medical, Portola Valley, CA, USA) was advanced over the guidewire and attached to the vein with sutures. The nervus cutaneous antebrachii medialis and fascia brachii were preserved. The basilica vein was dissected until the very proximal part was exposed and was cut from this end to be taken out of the tunnel (Figure 5). It was transposed to the subcutaneous tunnel that had been exposed in the biceps region at the antecubital fossa (Figure 6). Before vascular clamping, heparin was given at a dose of 100 U/kg. The anastomosis was made in an end-to-side fashion by using 7/0

Table 1. Distribution of Vascular Procedures for Hemodialysis Access of All Patients and the Division Percentage of Different Techniques on Diabetic Patients\*

Procedure Method	Group 1 (TBAVFs)	Group 2 (Non-TBAVFs)
Snuff-box	—	2 (28.16%)
Brescia-Cimino	—	12 (38.87%)
Forearm radiocephalic	—	20 (47.75%)
Antecubital brachiocephalic	—	12 (12.06%)
Prosthetic graft	2 (5.26%)	7 (14.3%)
Brachio basilic vein transposition	38 (100%)	0 (0%)
Total	38	49

\*TBAVF indicates transposed basilica vein arteriovenous fistula.

Table 2. Demographic Differences between Diabetic Patients with Transposed Brachio basilic Vein Arteriovenous Fistula (TBAVF) versus Different Arteriovenous Fistulas\*

	Diabetic TBAVF (n = 38)	Diabetic Non-TBAVF (n = 49)	Significance
Age, y	52.36 ± 3.26	48.6 ± 4.23	NS
Male	13 (34.21%)	18 (38%)	NS
Female	25 (65.79%)	31 (62%)	NS
Hypertension	6 (15.79%)	12 (24.5%)	NS
Cardiovascular disease	8 (35%)	27 (55%)	NS
Aspirin	24%	31%	NS
Warfarin	18%	21%	NS
Erythropoetin	32%	43%	NS
Mean operation time, min	106 ± 9.6	108 ± 12.3	NS
Smoker	28.5%	23.6%	NS
Median previous access (range)	1 (0-4)	1 (0-4)	NS
Early fistula primary patency	97.3%	73%	P < .05
Late fistula primary patency	94.7%	62%	P < .05
Late fistula secondary patency	84.2%	53%	P < .05

\*NS indicates not significant.

10-mm polypropylene material. The arteriotomy incision was a maximum of 5 mm in length. At the end of the anastomosis, only one knot was established, and it was not released until the appearance of a thrill. If an adequate thrill was not observed, the opening of the vein and anastomosis was controlled. A problem with the anastomosis was controlled using different methods. The mechanical dilatation is performed using Fogarty catheters and different sizes of dilatation devices. Topical diluted papaverine administration is another pharmacological dilatation method. If an adequate thrill was established, the subcutaneous and cutaneous tissues were closed surgically. The fistula was used for dialysis after an interval of 6 weeks. Patient records were examined retrospectively. Duration of follow-up and patency were recorded. Patency was assessed either by palpation for a thrill, auscultation for a bruit, or by using a Doppler probe. Primary patency was achieved when there was satisfactory flow in the fistula at 6 weeks without further intervention. Secondary patency, which includes an invasive procedure such as angioplasty or thrombectomy, was also noted. Cumulative secondary patency rates included those patients who developed both primary and secondary patency.

All variables are presented as mean ± standard deviation. Statistical procedures were performed using SPSS 13.0 (SPSS, Chicago, IL, USA). For the univariate analysis of demographic data, the chi-square and Fisher exact tests were performed. The Student *t* test was used to compare all other data. A value of *P* < .05 was considered statistically significant.

Table 3. Complications Related to Fistulas\*

	Diabetic TBAVF (n = 38)	Diabetic Non-TBAVF (n = 49)	Significance
Arm edema	3 (7.8%)	21 (40%)	$P < .05$
Hematoma	4 (1.5%)	14 (28.6%)	$P < .05$
Thrombosis	3 (7.8%)	13 (26.5%)	$P < .05$
Venous bleeding	2 (5.3%)	15 (30.6%)	$P < .05$
Lymph leakage	0	3 (6.1%)	NS
Infection	0	8 (16.32%)	$P < .05$
Nerve injury	0	2 (4%)	NS

\*TBAVF indicates transposed basilica vein arteriovenous fistula; NS, not significant.

## RESULTS

The retrospective review of 87 patients with diabetes and chronic renal failure revealed that 38 patients (group 1) had undergone the brachiobasilic vein transposition technique, whereas 49 patients (group 2) had undergone other techniques.

In group 1, 13 (34.21%) of the 38 patients were male and 25 (65.79%) were female. The analysis of age, weight, male or female sex, the history of hypertension, and other risk factors did not show any significant difference between groups ( $P = NS$ ). All patients (100%) had diabetes mellitus. Mean duration of follow-up was 8 months (range, 4-12 months) in both groups. The duration of the operation times was not statistically different (Table 2). No complications occurred in any of the cases.

The primary patency in the 38 patients of group 1 was 97.4% in the early period (6 weeks after the AVF) and 94.7% in the late period (mean duration of 8 months after the AVF). In the second group, these rates were 73% and 62%, respectively ( $P < .05$ ). The secondary patency rates were 84.2% in group 1 and 53% in group 2 after 8 months ( $P < .05$ ). For the entire series, there were no operative deaths (Table 2). The distribution of secondary patency rates in the second group showed that the BCAVF patients had primary and secondary patency rates in the first year of 87% and 78%, whereas the RCAVF patients demonstrated rates of 59% and 46% for primary and secondary patencies, respectively ( $P < .05$ ).

In group 1, 3 cases of brachiobasilic vein transposition (7.9%) maturation were not achieved, whereas, in group 2, the number of incidences was 8 (16.3%). Only 1 patient (2.63%) had an early occlusion and 2 patients (5.26%) had a late occlusion. The early occlusion was related to a thrombosis that did not resolve with adequate anticoagulation. The patient presented to the emergency late and no intervention was done. In the other 2 cases, nonmaturation was detected after 6 weeks when dialysis was started. The 2 patients (5.26%) with failed TBAVFs underwent revision to a polytetrafluoroethylene (PTFE) brachial artery-to-axillary vein AVF. The PTFE was required in 4 patients (16.6%) with failed BCAVFs and in 3 patients (15%) with failed RCAVFs.

The complications that were documented in each group

have been summarized in Table 3. The incidence of arm edema was 7.8% in group 1 versus 40% in group 2, hematoma was 1.5% versus 28.6%, thrombus was 7.8% versus 26.5%, bleeding was 5.3% versus 30.6%, and infection was 0% versus 16.3%. Group 1 had significantly fewer complications than group 2.

## DISCUSSION

The first hemodialysis access sites that are established in patients with chronic renal failure for a patent hemodialysis site are either radiocephalic or brachiocephalic fistulas. The National Kidney Foundation DOQI guidelines [NKF-K/DOQI 2001] recommend that patency rates of 70% at 1 year, 60% at 2 years, and 50% at 3 years should be achievable with all kinds of AVFs. In our study, the 1-year patency rate was 94.7% in group 1 versus 62% in group 2. Our study is limited, as we have no follow-up data available for 2 and 3 years.

The study by Hakaim et al is the only study that investigates and compares maturation and patency of different methods of hemodialysis-access procedures [Hakaim 1998]. The rate of nonmaturation of RCAVFs was 70%, whereas it was 27% for BCAVFs and 0% for TBAVFs ( $P < .05$ ). Primary patency rates were reported as a significant advantage for BCAVFs and TBAVFs at 18 months when compared with RCAVFs ( $P < .01$ ). The reasons for nonmaturation of RCAVFs in patients with diabetes remain to be defined. Patients who have a history of diabetes commonly display medial calcification, and this may prevent increased flow through an AVF and prevent arterial dilatation. In the study by Hakaim et al, 6 patients who had nonmaturing BCAVFs underwent creation of an ipsilateral brachial artery-to-axillary vein PTFE AVF [Hakaim 1998]. However, in our study, this approach was used in 2 patients (3.62%) with failed BCAVFs in the second group. In group 2 of our study, the BCAVFs showed primary and secondary patency rates at first year of 87% and 78%, whereas RCAVF patients demonstrated primary and secondary patency rates of 59% and 46%, respectively. The RCAVFs have a statistically significant lower patency rate than TBAVFs. This finding



Figure 5. The basilica vein was released and the tip was brought near the brachial artery for preparation of anastomosis at the antecubital fossa.



Figure 6. The basilica vein was transposed from its released position to be ready for anastomosis at the antecubital fossa by using the guidewire through the tunnel that was prepared in the subcutaneous region.

supports the hypothesis that the TBAVF procedure is a significantly better procedure in diabetic patients and can be recommended not only as a secondary-access procedure but also as a primary-access procedure for hemodialysis-access procedures in patients with chronic renal failure.

The primary patency rate for brachio basilic transposition fistula has been reported in a recent study by Taghizadeh et al [2003] during a median follow-up of 14 months as 92%, and a cumulative secondary patency rate was reported as 99% at 1 year. Complications occurred in 41 (55%) of the patients, with some patients having more than one complication. These included thrombosis of the fistula in 33%, stenosis in 11%, arm edema in 5%, bleeding in 2%, and steal syndrome in 1%. Local infection occurred in 8%, necessitating ligation of the fistula in 3%. In this study, 37% of the patients had diabetes. The relation between the diabetic patients and the risk of developing complications was not mentioned in the Taghizadeh study [2003].

In the study by Rao et al, 57% of patients had diabetes, and basilica vein transposition was the primary access procedure in 39% of patients [Rao 2004]. Maturation failure occurred in 38% of patients, and primary and secondary patency rates at 1 year were 35% and 47%, respectively. Considering only those that matured and were accessed, primary and secondary patency rates at 1 year were 53% and 75%, respectively. Forty-two percent of patients whose AVFs failed to mature underwent a successful placement of a prosthetic graft in the ipsilateral arm. In the Rao study, they reported lower maturation and patency rates for patients older than 60 years of age undergoing transposition of basilica vein AVFs [Rao 2004]. Our patient population was from a younger age group, and only 3 patients were older than 60 years of age. For this age group, the results were not statistically different than for other patients undergoing TBAVFs ( $P < .05$ ).

Preoperative duplex ultrasound assessment has been shown to improve successful fistula creation rates [Murphy 2002]. This assessment has not been included in our study protocol because the use of ultrasound scanning might show a

small diameter basilica vein that may prevent the surgeons from performing the transposition procedure [Rao 2004]. In our study, the vein to be used was determined by physical examination with tourniquet compression.

In the study by Taghizadeh et al, complications occurred in 55% of the patients and these included thrombosis of the fistula in 33%, stenosis in 11%, arm edema in 3%, bleeding in 3%, and steal syndrome in 1% [Taghizadeh 2003]. In the study by Murphy et al [2002], the secondary patency rate for transposed basilica vein to brachial artery AVFs was 73% at 1 year, and the most common complications were arm edema (24%), thrombosis (22%), and bleeding (18%). In our study, there were no infections seen in group 1, whereas, in group 2, the rate was 12%. As in the study by Murphy et al [2002], the most common complication in our study was also arm edema (16%), followed by thrombosis (9%) and bleeding (8%).

There are studies in the literature that are contrary to our findings and do not consider diabetes as a risk factor for late maturation. In the study by Patel et al, sex, race, diabetes mellitus, previous failed access, and vein diameter (2.5-3 cm versus  $>3$  cm) did not affect probability of maturation [Patel 2003]. The study by Wolford and colleagues [2005] demonstrated that, in 100 basilic vein procedures, the maturation rate was 79%. The most common cause of failure of a matured fistula was stenosis within the body of the basilica vein (44%), and there was no significant impact of history of diabetes on the rate of maturation.

## CONCLUSION

Chronic renal failure affects patients medically as well as socially, economically, and psychologically. With the use of hemodialysis, the survival and comfort of millions of chronic renal failure patients has increased. There are not enough data on the preferable hemodialysis-access technique for diabetic patients in the literature. The failure of maturation and lower patency rates in patients with diabetes with different hemodialysis techniques have led us to compare the keyhole transposed basilica vein technique with all other hemodialysis techniques. Although the study group is small, the success rate was extremely gratifying. The risk of infection, rupture, aneurysm formation, and occlusion were higher with all other hemodialysis graft techniques. The keyhole technique for basilic vein transposition can be considered the first attempted hemodialysis-access procedure in patients with diabetes.

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