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Outcomes of Brachial Artery–Basilic Vein Fistula

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ABSTRACT

Increasing the creation of arteriovenous fistulas in the maintenance of hemodialysis patients is of great importance to the nephrology community. The creation of the brachial artery–basilic vein fistula is an important option in patients with unsuccessful or failing forearm accesses for hemodialysis. The aim of this study is to review reported outcomes of brachial artery–basilic vein fistulas regarding patency and primary failure rates in comparison with other types of fistulas and grafts in the published literature. We have also described the variations in the surgical technique during creation and the potential influence on outcomes. Based on our review of the literature, the rate of primary failure is approximately 15–20% with a range of 0–40%. The mean 1-year primary patency rate is approximately 72% with a range of 23–90%, and the 2-year primary patency rate is approximately 62% with a range from 11% to 86%. The number of required interventions to maintain patency is lower with brachial artery–basilic vein fistula compared to arteriovenous grafts.

The 2006 Kidney Disease Outcome Quality Initiative (K/DOQI) Clinical Practice Guidelines in Vascular access recommends placement of autologous arteriovenous access in the following decreasing order of preference: radiocephalic arteriovenous fistula (AVF) at the nondominant wrist, brachiocephalic AVF (BCF) at the elbow, transposed brachial-basilic vein fistula (BBAVF) and arteriovenous graft (AVG) in the upper arm in suitable patients (1). Dagher et al. (2,3) first described the transposed brachial artery–basilic vein AVF in 1976. The BBAVF is more time consuming and technically challenging when compared to the BCF or AVG. The depth of the basilic vein renders it free from iatrogenic vein punctures, but successful cannulation almost always requires superficialization. The exception occurs in the patient with an extremely thin arm. The course of the vein, in close proximity to the medial antebrachial cutaneous nerve, the brachial artery, and the median nerve, places these structures at risk of injury and may result in pain from repeated cannulation during dialysis. As a result, in addition to superficialization, the vein is usually transposed anteriorly and laterally to displace it from these structures.

Although the basilic vein has a relatively larger diameter (usually greater than 3mm), the vessel wall is thinner and it has many more tributaries, compared to the cephalic vein. These properties of the basilic vein also make it more prone to injury and devascularization during dissection, which may lead to subsequent stenosis and thrombosis. Transposition is achieved by either tunneling the vein via a new subcutaneous plane or simple creation of a lateral skin flap. Tunneling can place the basilic vein at risk of kinking, stretching, or trauma, particularly at the swing segment. This can result in sudden postoperative occlusion. For these reasons, some surgeons advocate a two-stage technique, in which the anastomosis is first created, and the basilic vein is later mobilized once it has become "arterialized." In contrast, the cephalic vein is almost always left in situ as it travels quite superficial in the lateral arm in an optimal position for cannulation and is superficialized only in select cases. Thus, the technical skills of the surgeon are a crucial factor in the early success of AV access procedures, and for the aforementioned reasons, this appears to be especially true for BBAVF.

The goals of this study are first to describe the various techniques of BBAVF, second, to review the published literature with regard to primary failure rates as well as primary and secondary patency rates of BBAVF, third, to compare one-stage and two-stage BBAVG with respect to primary failure, patency, and complication rates, and finally, to compare the relative patency rates of BBAVF with BCF and AVG.

Methods

Search words "BBAVF," "brachial-basilic arteriovenous fistula," "basilic vein elevation," "basilic vein transposition," and "basilic vein fistula" were entered

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into PubMed, Medscape, and Medline databases to identify all published reports in the English literature. The reference lists of all relevant articles identified were cross-referenced by two independent reviewers. Only full-length published articles are included in this study.

Studies were found between 1976 and 2009, and most report outcomes retrospectively. Forty studies directly relevant to the goals of this study are summarized in Table 1. A single review paper summarizing outcomes of BBAVF studies performed prior to 2004 was included (4). Seven prospective studies were found including two randomized studies, as well as one randomized study comparing one-stage versus two-stage BBAVF (5). The other randomized study compared BBAVF with BCAVF (6). The limitations of studies have been summarized in Box 1.

Definitions used are in accordance with the Society of Vascular Surgery and the American Association of Vascular Surgery document from 2002 published in accordance with recommendations from NKF-DOQI. Primary patency is defined as the interval from the time of access placement until any intervention designed to maintain or reestablish patency, access thrombosis, or the time of measurement of patency. Primary assisted patency is defined as the interval from the time of access placement until access thrombosis or the time of measurement of patency, including intervening manipulations (surgical or endovascular interventions) designed to maintain the functionality of a patent access site. Secondary patency is the interval from time of access placement until site abandonment, thrombosis, or the time of measurement of patency including intervening manipulations designed to restore functionality in a nonworking access site. The word “functional” may be added to patency rates in order to indicate a patency period beginning at first successful dialysis rather than surgical access placement.

Description of Surgical Technique

The procedure is performed under local anesthesia, interscalene nerve block, or general anesthesia. In the vast majority of patients, general anesthesia is not necessary. Our preferred technique is local anesthesia for the initial procedure. However, regional block has the advantage of rendering the arm immobile during the anastomosis and has the advantage of inducing venodilation via inhibition of sympathetic fibers, permitting better visualization of the veins. In the second stage of the two-stage procedure, we prefer a regional block to avoid a large amount of local anesthesia owing to the extensive dissection.

One-Stage Procedure

A 2-cm transverse incision is made proximal to the antecubital crease to expose the brachial artery. An interrupted or continuous longitudinal incision is made at the medial side of the upper arm and is made to dissect the basilic vein (Fig. 1). The basilic vein is mobilized along the entire upper arm, and visualized tributaries are ligated. The basilic vein is transected as distal as possible. Care must be taken to preserve the medial brachial cutaneous nerve as it runs close to the basilic vein. A bulldog clamp is placed at the proximal end of the basilic vein, and either saline or dilute papaverine is gently injected into the basilic vein to dilate it. Care must be taken to avoid overdistention, as this may lead to intimal injury and resultant intimal hyperplasia.

The vein is (i) transposed to the anterior arm with the use of a tunneling device, (ii) transposed to the anterior upper arm under a lateral flap of skin or (iii) simply superficialized without transposition. All methods attempt to place the fistula approximately 6 mm beneath the skin for ease of dialysis access.

If a tunneling is chosen, it must be performed prior to the brachial artery anastomosis. A subdermal tunnel with a diameter of at least 10 mm is created lateral, anterior, and superficial to the basilic vein position in the upper arm. The basilic vein is pulled through the tunnel with care not to kink, twist, or traumatize the vein. Alternatively, a skin flap is created in the subcutaneous tissue laterally and anteriorly, and the deeper layer is closed over the native basilic vein site to protect and displace the fistula from the deeper structures including the artery and medial antebrachial cutaneous nerve. The basilic vein fistula is then positioned in the lateral portion of the subcutaneous pocket. The third technique used by some surgeons is to simply superficialize, or “elevate,” the vein overlying its native position in the medial arm without lateral transposition. The underlying subcutaneous tissue is closed beneath the vein, and the overlying skin is closed.

The role of heparinization is controversial. Either heparin can be given systemically or dilute heparin is injected directly into the basilic vein and the brachial artery is clamped. A 6-mm arteriotomy is made in the side of the brachial artery, and an end-to-side anastomosis is performed using running 6–0 prolene suture without excessive tension on the basilic vein in its new position.

A fourth technique less commonly described involves endoscopic harvesting of the basilic vein via keyhole technique that decreases the size of the surgical scar and extends the length of the operation (7).

Two-Stage Procedure

In the two-stage procedure, the basilic vein and brachial artery are exposed via a similar two-cm incision just proximal to the antecubital crease. The vein is anastomosed to the artery without initial superficialization. Following a variable time period of 30–90 days, the basilic vein is then mobilized in the second stage of the procedure using one of the three described methods. If transposition is performed with the use of a tunneling device, the fistula must be divided and reanastomosed in an end-to-end fashion.

One-Stage versus Two-Stage

The potential advantages of the one-stage procedure include earlier functional patency with shorter duration of catheter use as there is no need for a second-stage

TABLE 1. Selected published studies of brachial artery–basilic vein fistula

Author	Year of publication	Number of BBAVF	1-stage	2-stage	Patency rates	Primary failure rates of BBAVF	Description of the study
Dagher (3)	1976	24	Yes	No	8-month PPR of 92% SPR N/S	N/S	Retrospective study
LeGerfo (17)	1978	25	Yes	No	12-month PPR 85% SPR N/S	N/S	Retrospective single-center study
Barnett (18)	1979	16	Yes	No	9-month PPR 94% SPR N/S	N/S	Prospective nonrandomized single-center study
Dagher (19)	1980	90	Yes	No	12-month PPR of 78%	N/S	Retrospective study
Cantelmo (20)	1982	68	Yes	No	12-month PPR of 70% 36-month PPR of 57.2%	N/S	Retrospective single-center study
Koontz (21)	1983	12	Yes	No	12-month PPR of 75%	N/S	Retrospective single-center study
Dagher (22)	1986	96	Yes	No	PPR is 70% Follow-up n/a	N/S	Retrospective single-center study
Davis (23)	1986	66	Yes	No	PPR is 83.3% Follow-up n/a	N/S	Retrospective single-center study
Hibberd (24)	1991	15	Yes	No	12-month PPR of 70%	N/S	Nonrandomized Prospective study
Hatjibaloglou (25)	1992	25	Yes	No	12-month PPR of 81%	N/S	Retrospective single-center study
Rivers (26)	1993	65	Yes	No	12-month SPR 55% 30-month SPR of 49%	N/S	Retrospective single-center study
Elcheroth (27)	1994	80	Yes	No	12-month PPR of 76.7% 48-month PPR of 49.2%	N/S	Retrospective single-center study
Coburn (13)	1994	59 BBAVF 47 BAAVG	Yes	No	12-month PPR 90% 24-month SPR of 86% for BBAVF 12-month PPR 70% for BAAVG	N/S	Retrospective single-center comparison of BBAVF and BAAVG
Stonebridge (28)	1995	19	Yes	No	16-month PPR of 79%	N/S	Retrospective single-center study
El Mallah (5)	1998	20 1-stage 19 2-stage	20	19	16 ± 3.5-month PPR of 50% in 1-stage 14.8 ± 5-month PPR was 80% in 2-stage	1-stage was 40% 2-stage was 10%	Randomized Prospective trial comparing 1-stage and 2-stage
Butterworth (29)	1998	23	Yes	No	8-month PPR of 78.3%	N/S	Retrospective single-center study
Matsuura (42)	1998	30 BBAVF 68 AVG	Yes	No	24-month PPR of 70% for BBAVF, 46% for AVG	N/S	Retrospective comparison of BBAVF with PTFE grafts.
Hakaim (12)	1998	26 BBAVF 22 BCAVF 10 RCAVF	Yes	No	18-month CPPR for BBAVF 79%, BCF 78% RCAVF 33%	0% for BBAVF 27% for RCAVF 70% for RACVF	Prospective randomized comparison of BBAVF, RACVF, BCF
Humphries (8)	1999	67 1-SE	Yes	No	12-month PPR of 84% 73% at 3 and 5 years 52% at 10 years	N/S	Retrospective single-center one-stage elevated BBAVF
Murphy (9)	2000	74 24 NU 50 AP	Yes	No	1-year CSPR 73%, 2-year 53%, and 3-year 43%	17.6%	Retrospective analyses in one center
Oliver (43)	2001	59 BBAVF 82 upper arm AVG 56 BCF	Yes	No	1-year PPR 64% for BBAVF, 64% for BCF, and 62% for AVG	21% for BBAVF 15% for AVG 32% for BCF	Retrospective comparison of BBAVF with BCF and upper arm grafts at single center.
Gibson (30)	2001	181	Yes	No	12-month PPR 44% SPR 68% 24-month PPR is 28% SPR 60%	N/S	Retrospective single-center study
Dahduli (31)	2002	16	Yes	No	6-month PPR 85% SPR n/a	N/S	Retrospective single-center study
Tsai (32)	2002	54	Yes	No	12-month PPR 90% SPR 96% 24-month PPR 73% SPR 85%	N/S	Prospective single-center study

Table 1. (*Continued*)

Author	Year of publication	Number of BBAVF	1-stage	2-stage	Patency rates	Primary failure rates of BBAVF	Description of the study
Hossny (39)	2003	70 30 TP 20 1-SE 20 2-SE	30 TP	40 No TP	TP 12-month CSPR 86.7% 24-month CSPR 82.8% 1-SE 12-month CSPR 90% 24-month 70% 2-SE CSPR 12-month 84.2% 24-month 68.4%	5.7%	Retrospective singe-center study comparing outcomes between transposed and elevated only BBAVF.
Segal (33)	2003	99	Yes	No	1-year PPR 47% 2-year PPR 41%	23%	Retrospective single-center study
Taghizadeh (34)	2003	75	Yes	No	1-year PPR 92% 1-year CSPR 66% 2-year CSPR 52% 3 year 43%	8%	Retrospective single-center study
Rao (35)	2004	56	Yes	No	1-year PPR 35% 1-year SPR 47%	38%	Retrospective single-center study
Fitzgerald (44)	2004	32 BBAVF 23 IS 9 NS 39 BCF 15 BMAC	Yes	No	7.1 ± 7.9 months PPR 75% IS 7.9 ± 8.7 mos. 78% NS 4.5 ± 2.9 mos. 67%	25%	Retrospective single-center outcomes of upper arm AVF
Wolford (36)	2005	100	Yes	No	1-year PPR 23 ± 5% 2-year PPR 11 ± 5% 1-year SPR 47 ± 6% 2-year SPR 40 ± 10%	21%	Retrospective single-center study
Weale (45)	2007	71 BBAVF 114 BAAVG	Yes	No	12-month PPR 45% for BBAVF, 12-month PPR 56% for BAAVG	25.3%	Retrospective comparison of BBAVF and BAAVG
Francis (40)	2007	91	No	Yes	12-month PPR 87% SPR 89% 24-month PPR 78% SPR 84%	N/S	Retrospective single-center study
Woo (10)	2007	119 BBAVF 71 CVT 164 AVG	Yes	No	5-year PPR 52% SPR 62% for BBAVF 5-year PPR 40% SPR 46%	N/S	Retrospective single-center study comparing basilic and cephalic vein transposed fistulas and upper arm grafts
Pflederer (47)	2008	161 TAVF	No	156 2-stage BBAVF 156 2-stage BBAVF	12-month PPR 58% 24-month 44% for BBAVF	19.25%	Retrospective single-center study of outcomes of BBAVF with nontransposed AVF and AVG
Chemla (48)	2008	34 BBAVF 42 BAAVG	Yes	No	12-month PPR 73% 24-month 69% 12-month APPR 96% 24-month 74% 12 SPR 93% 24-month 85%	0%	Prospective nonrandomized comparison of BBAVF and BAAVG
Keuter (14)	2008	52 BBAVF 53 FLG	Yes	No	BBAVF 12-month PPR 46%±7.4%, APPR 87%±5% SPR 89% ± 4.6% FLG PPR 22%± 6.1% APPR 71%± 6.7% SPR 85%± 5.2%	4%	Randomized multicenter (3 hospitals)study comparing forearm loop graft (FLG) with BBAVF

Table 1. (*Continued*)

Author	Year of publication	Number of BBAVF	1-stage	2-stage	Patency rates	Primary failure rates of BBAVF	Description of the study
Moosavi (11)	2008	58 (46 analyzed)	Yes	No	3-year PPR 38.3 ± 7.7% SPR 56.5% ± 12.6%	17.2%	Retrospective single-center study. BBAVF outcome compared with 30 first AVG and 28 first AVF.
Harper (37)	2008	168	Yes	No	1-year PPR 59 ± 4.0 %, 2 years 38 ± 3.8%, 3 years 30 ± 5.0% 1-year SPR 66 ± 4.1%, 2 years 49 ± 4.8%, 3 years 39 ± 5.7%	23%	Retrospective single-center study
Maya (49)	2009	67 BBAVF 322 BCF 289 AVG	Yes	No	MCAS is 1494 days for BBAVF 1254 days for BCF 595 days AVG	18% for BBAVF 15% for AVG 38% for BCF	Retrospective single-center analysis of 3 upper arm access BBAVF, BCF, AVG
Koksoy (6)	2009	48* BBAVF 45* BCAVF	Yes	No	BBAVF 1-year PPR 86% 3 years 73% SPR 1 year 88%, 3 years 71% BCAVF 1-year PPR 87%, 3 years 81%, SPR 1 year 87%, 3 year 70%	4% BBAVF 10% BCF	Prospective randomized study comparing BBAVF with BCAVF
Glass (38)	2009	217	Yes	No	6-month PPR 63%, 12 months 40%, 24 months 26%; APR at 6 months 74%, 12 months 56%, 24 months 38%; SPR at 6 months 85%, 12 months 72%, 24 months 65%	13%	Retrospective analysis of BBAVF single center

PPR, primary patency rate; APPR, assisted primary patency rate; SPR, secondary patency rate; CSPR, cumulative secondary patency rate; PFR, primary failure rate; BCF, brachial artery–cephalic vein fistula; BBAVF, brachial artery–basilic vein fistula; RCAVF, radiocephalic AVF; AVF, arteriovenous fistula; AVG, arteriovenous graft; FLG, forearm loop graft; BCAVF, brachial artery–cephalic vein fistula; CVT, cephalic vein transposition; tAVF, transposed arteriovenous fistula; IS, immediate superficialization; NS, no superficialization; BAAVG, brachial artery–axillary vein AVG; mos, months; BMAC, brachial artery–antecubital vein fistula; MCAS, median cumulative access survival, which is time from creation to permanent failure when primary failure is excluded. 1-SE, 1-stage elevation; 2-SEm, 2-stage elevation; N/S, not stated or not available; NU, never used; AP, number used in patency rates.

*50 patients were in the BBAVF group and 50 patients were in the BCAVF group. Seven patients had AVF which never matured and were not included in the patency analysis according to the authors.

Box 1. Limitations of published studies of brachial artery–basilic vein fistula

Primary failure rates were not reported and if reported were not included in the final analysis of primary patency rates.
Follow-up period to report primary or secondary patency rates is not uniform, and therefore, some studies have reported 12-month primary patency rates and the other have reported another time period of follow-up.
Selection of subjects for BBAVF in some reports has been based on preoperative vein mapping size, which is not uniform across studies. Some reports have used basilic vein size greater than 2.5 mm as eligible, and the others have used 3.0 mm and above.
Preoperative vein mapping was not carried out or not reported in some studies, and the choice of vein mapping was not identical.
Reporting of the presence of if any ipsilateral central venous catheters or central venous stenosis was not uniform.
Methodology in reporting of complication rates was not standardized.
Inadequate power of the chosen cohort.
Technical failure rate is included in the primary failure rate.

procedure. The potential advantages of a two-stage procedure include the ease of mobilization with a larger "arterialized" more thick-walled vein. This may also render it less susceptible to torque and devascularization during mobilization at the second stage. Some surgeons have described the ease of basilic vein dissection and an overall decrease in operative times when using the two-stage procedure. A clear drawback for the two-stage procedure is prolonged catheter use during the period between the two stages with the associated complications of catheter-related bacteremia, central venous stenosis, and malfunction leading to substantial increases in morbidity and mortality. This is negated if access is placed at a time allowing for maturation prior to initiation of dialysis.

Fig. 1.

Results

There are no data available at this time to bear credence to one procedure over the other apart from a single prospective, randomized study that directly compared the one-stage with the two-stage operation (5). In our study of one and two-stage operations at two centers, we find statistically improved patency rates with the two-stage operation. In the United States, the decision is based on surgeon preference and training background. There also appears to be regional differences in the United States. The two-stage procedure is more common in Europe than in the United States.

Primary Failure Rates: Primary and Secondary Patency Rates for BBAVF

In determining whether to perform a BBAVF, it is important to have a good sense of the anticipated patency rates. One must exercise caution in the interpretation of the reported rates as the majority of studies did not include the primary failure rate. This likely artificially increased the reported patency rates and also makes it difficult to distinguish primary patency from functional patency. The limitations of interpreting these studies have been summarized (refer to Box 1). Table 1 summarizes patency rates of studies that did not include primary failure. There is a wide range of reported patency rates for one-stage BBAVF at 1 year from 44% to 90%. Given that the duration of follow-up for these reports varies considerably, it is difficult to calculate the average patency. However, Dix et al. (4) have reviewed patency rates of BBAVF from 1976 to 2004 and calculated a mean 12-month primary patency rate of 72% and a secondary patency rate of 74.6%. Again, these data may be misleading, as most of the studies did not include the primary failure rate.

In addition to the study by Hossny et al. discussed later, one other study examined long-term outcomes with superficialization alone. Humphries et al. retrospectively reviewed 67 patients over a 10-year period. Criteria for the study included superficialization of at least 8 cm of basilic vein and a basilic vein diameter of at least 4 mm (8). Actuarial fistula patency, with failure defined as graft thrombosis or ligation, was reported at 1 year to be 84%, 73% at 5 years, and 52% at 10 years. In this study, it appears "actuarial" patency is the equivalent of secondary patency. In addition, it appears that no successful interventions were performed in these patients that would cause primary and secondary patency rates

TABLE 2. Patency rates for BBAVF (discussed in text)

Author	Description of study	Number of patients	Primary failure (%)	PPR/SPR 1 year (%)	PPR/SPR 2 year (%)	PPR/SPR 3 year (%)
Murphy 2000 (9)	Retrospective	74 (24 nu)	17.6	–/73	–/53	–/43
Segal 2003 (33)	Retrospective	99	23	47	41	
Taghizadeh 2003 (34)	Retrospective	75	8	–/66	–/52	–/43
Francis 2007 (40)	Retrospective	91	N/S	87/89	78/84	
Harper 2008 (31)	Retrospective	168	23	59/66	38/49	30/39
Glass 2009 (38)	Retrospective	217	13	40/72	72/65	

BBAVF, brachial artery–basilic vein arteriovenous fistula.

TABLE 3. BBAVF versus BCF versus AVG

Author	Description of the study	Number of patients	PF (%)	PPR/APR/SPR 1 year (%)	PPR/SPR 2 years (%)	PPR/SPR 5 years (%)
Oliver 2001 (43)	Retrospective	59 BBAVF	21	64		
		82 AVG	15	62		
		56 BCF	32	64		
Pflederer 2008 (47)	Retrospective	161 BBAVF (156 2-SE)	19.25	58/97	44/97	
		321	24.61			
		203 RCF		41/60	20/52	
		118 BCF		59/77	48/75	
		285 AVG	10.88	18/66	5/54	
Maya 2009 (49)	Retrospective	67 BBAVF	18	Data reported as MCAS		
		322 BCF	38			
		289 AVG	15			
Moossavi 2008 (11)	Retrospective	58 BBAVF	17.2			38.3/56.5
Woo 2007 (10)	Retrospective	119 BBAVF		71/76		52/62
		71 BCF (transposition)		56/66		40/46
		164 AVG		34/63		14/17
Koksoy 2009 (6)	Prospective randomized	50 BBAVF 1st	4	86/88		73/71
		50 BCAVF	10	87/87		81/70
Hakaim 1998 (12)	Retrospective	26 BBAVF	0	–/79 (18 mos)		
		22 BCF	27	–/78 (18 mos)		
		10 RCF	70	–/33 (18 mos)		
Keuter 2008 (14)	Prospective randomized	52 BBAVF	4	46/87/89		
		53 forearm loop AVG		22/71/85		
Kakkos 2008 (15)	Retrospective	76 BBAVF	–	46/82/87		
		41 AVG	–	50/70/88		
Coburn 1994 (13)	Retrospective	59 BBAVF	–	90/70/24	90/70	
		47 AVG	–	86/87	49/64	

BBAVF, brachial artery–basilic vein fistula; BCF, brachial artery–cephalic vein fistula; AVG, arteriovenous graft.

to differ. Twenty-one percentage of were lost owing to thrombosis and 6% owing to ligation for arm swelling. These data demonstrate the importance of analyzing each study when attempting to assess outcomes.

The studies in Table 1 provide primary failure rates for BBAVF. The six studies that reported primary failure rates range from 5% to as high as 40%. The 1-year primary patency rates for these studies range from 47% to 84%.

Complication rates in these studies were high. Taghizadeh et al. reported a 55% complication rate in 75 BBAVF. In another study, Segal et al. noted that the presence of ipsilateral central venous catheter increased the risk of BBAVF failure threefold (RR 2.92, CI 1.34–6.38, $p < 0.01$). The primary access failure was affected by previous vascular access (RR 6.4, CI 1.49–27.6, p .001), obesity (RR 7.1, CI 1.65–30.1, $p < 0.05$), and older age (RR 2.0, CI 1.20–3.38, $p < 0.01$). Murphy et al. (9) noted that of 74 BBAVF in 65 patients, 24 (32%) were never used, 11 of which were not used owing to primary failure. The authors reported a 69% complication rate owing to high-risk patients in this cohort. Fifty-seven percentage of the patients had ipsilateral subclavian catheters at a median of one catheter per patient. Harper et al. in a study of 168 BBAVF reported that 34% were never used of which 23% were attributable to fistula failure. Failure was owing to thrombosis or inadequate maturation in 14 each, and two were owing to poor flow.

In the largest series of BBAVF to date, Glass et al. recently reported only a 40% primary patency at 1 year and 26% at 2 years in 217 one-stage BBAVF. Secondary patency rates were 72% and 65% at 1 and 2 years, respectively.

One-Stage versus Two-Stage BBAVF Procedure (Table 5)

The decision of whether to perform a one- or two-stage BBAVF remains controversial. The literature offers little data to address this issue. In the only prospective randomized trial, El Mallah randomized 40 patients to one-stage or two-stage (2–4 weeks after first stage) procedure (5). Primary patency was

TABLE 4. BBAVF versus AVG versus BBrAVF

Author	Description of the study	Number of patients	PF (%)	PPR/APPR/SPR 1 years (%)	PPR/SPR 2 years (%)	PPR/SPR 5 years (%)
Casey 2008 (26)	Retrospective	42 BBAVF	26	50		
		17 BBrAVF	53	40		
Torina 2008 (27)	Retrospective	42 BBAVF (38 1st, 4 2nd)		45/74		
		94 AVG		50/78		
		13 BBrAVF (11 1st, 2nd)		24/45		

BBAVF, brachial artery–basilic vein fistula; AVG, arteriovenous graft; BBrAVF, brachial artery–brachial vein fistula.

TABLE 5. One-stage versus two-stage BBAVF

Author	Description of the study	Number of patients	PF (%)	PPR/SPR 1 year (%)	PPR/SPR 2 years (%)	PPR/SPR 3 years (%)
El Mallah 1998 (5)	Prospective randomized	20 one-stage	40	> 50		
		19 two-stage	10	> 80		
Hossny 2003 (14)	Retrospective	30 one-stage trans	6.7	–/86.7	–/82.8	
		20 one-stage no trans	5	–/90	–/70	
		20 two-stage no trans	5	–/84.2	–/68.4	
Humphries 1999 (15)	Retrospective	67 one-stage no trans		84		73

BBAVF, brachial artery–basilic vein fistula.

achieved in 60% for the one-stage versus 90% for the two-stage ($p < 0.05$). Likewise, there was a statistically greater overall primary patency rate in the two-stage procedure at 15 months (50% versus 80%, $p < 0.005$).

Hossny et al. compared three approaches, 1-stage with transposition (30 patients), 1-stage with superficialization alone (20 patients), and 2-stage with superficialization alone (20 patients). No patients received a 2-stage transposition. The total complication rate was higher in the superficialized fistulas (71.4%) than in the transposed ones (28.6%, $p < 0.001$). Hematoma was more common the superficialized group (26.3%) than in the transposed group (3.6%) and was considered the major predisposing factor in fistula failure, as nearly 63.7% of thrombosed fistulas were preceded by hematoma. No statistically significant difference in cumulative secondary patency rates between the groups was seen, despite the higher complication rate in the superficialization group. Interestingly, the study reported dialysis nurse satisfaction with the two types of BBAVF. One hundred percentage of were satisfied with transposed veins, while only 53.7% were satisfied with the superficialized-only veins. Transposition is favored by dialysis staff who deal with access on a daily basis.

BBAVF versus Other Upper Extremity Fistulas and AVG (Table 3)

Several studies have compared results of BBAVF with other access procedures, and patency rates are summarized in Table 3. It is now readily apparent that AVG have poorer long-term patency rates than AVF resulting in fistula first initiatives. Although primary failure rates are often lower with AVG, long-term patency should be the primary endpoint of study. Complication rates are discussed here rather in table format because of difficulty with standardization. Oliver et al. noted that upper arm grafts, compared with BBAVF, were more likely to thrombose (RR of 2.6, 95% CI 1.3–5.3), required more interventions (2.4 versus 0.7 per access-year, $p < 0.001$), and were more likely to become infected. Mature BCF showed a trend for less thrombosis and were less likely to fail. Primary failure of BBAVF was 21%, BCF was 32%, and AVG was 15%. It must be noted however that when primary failure was included in analysis, there was no significant difference in failure-free survival (cumulative patency) between the three types of access. Choi et al. noted that cumulative patencies in transposed fistulas were higher than nontransposed AVF or AVG. Woo et al. (10) found statistically similar patency rates in BBAVF and BCF. On multivariate analysis, the primary patency rate was affected by history of previous upper arm access, whereas the secondary patency was lower in those with a history of upper torso dialysis catheters. Transposed upper arm fistulas had higher patency rates than AVG and required fewer revisions. Primary failure rates were not reported. In one of the largest series to date, Pflederer et al. reported that the primary failure rate was significantly higher for AVF (19%) than for AVG (11%). However, AVF were superior to AVG in primary patency at 1 year (58% versus 18%) and secondary patency (97% versus 66%). The authors favored the 2-stage procedure as the majority of failures and complications (81%) occurred before the transposition of the basilic vein. The authors delayed the second stage of the operation until 2–3 months prior to the anticipated initiation of hemodialysis. The majority of BBAVF were used successfully at median time of 56 days after the second-stage procedure. Maya et al. reported that primary failure was lower for BBAVF (18%) and AVG (15%) than for BCF (38% CI 1.41–5.38, $p < 0.003$). Total annual interventions were lower for BBAVF (0.84 interventions per year) and BCF (0.82 interventions) compared to AVG (1.87 $p < 0.001$).

The report by Moosavi et al. (11) is noteworthy for the long-term follow-up of 58 BBAVF. The median survival of 46 BBAVF (10 were lost owing to primary failure, 2 patients expired with functioning access) was 76.8 months compared with 21.4 months with AVG. The median time interval to first intervention was 11 months for BBAVF compared to 8.3 months for AVG. It becomes apparent that caution must be used when analyzing patency rates in some studies. For example, primary patency for BBAVF is reported as 38.3% at 3 years. However, if the 10 patients who underwent primary failure are included, the primary failure rate drops to approximately 31.4%. Of note, the primary patency for AVG in the same study is 0% at 3 years. From these studies, the BBAVF is an excellent option for AVF when other distal access is not available and should be used prior to AVG when possible.

Comparison of BBAVF with BCF

Several studies have compared BBAVF with BCF. In a single-center, prospective, randomized study by Koksoy et al., 100 patients were randomized to either BBAVF or BCF (6). An important enrollment criterion was a minimum vein diameter of 3 mm. All procedures were performed as one-stage procedures under local anesthesia. AVF in seven patients (2 BBAVF, 5 BCAVF) did not mature and were not included in the patency analysis. Although the mean caliber of the basilic veins was larger (4.51 versus 3.90 mm $p = 0.002$), there was no significant difference in primary or secondary patency rates. Complication rates were also similar. Woo et al. also concluded that BBAVF and BCF had similar patency rates. Koksoy, conversely, reported that the maturation rates were slightly higher for BBAVF (96%) compared to BCF (90%) and mean time to maturation was shorter with BBAVF although these findings did not reach statistical significance. Multivariate analysis did not show age or gender to have a statistically significant effect on the patency rates. There was also no difference in steal syndrome. In a series of patients with diabetes, Hakaim et al. (12) found a 0% nonmaturation rate for transposed BBAVF compared to 27% with BCF. Thus, it appears that when comparing BBAVF with BCF, the data demonstrate similar outcomes. The BCF is technically easier to perform as it usually requires no superficialization and should be used prior to BBAVF when possible.

Comparison of BBAVF with Upper Arm AVG

In a single-center study in 1994 by Coburn et al. (13), 59 one-stage transposed BBAVF were compared with 47 PTFE AVG. Primary patency for BBAVF at one and 2 years was 90% and 86% compared with 70% and 49% for AVG. Secondary patency rates at one and 2 years were 90% and 70% for BBAVF, compared to 87% and 64% for AVG. Complications occurred 2.5 times more frequently in AVG. In a randomized multicenter study, Kueter et al. (14) compared 52 BBAVF to 53 forearm AVG using PTFE. Of note, Duplex scanning was performed preoperatively in all participating patients. A diameter of 3 mm for the basilic vein was preferred, but the authors reported that the quality of the vein was considered more important in the choice of creating a BBAVF. One-year primary patency rates were higher ($p = 0.005$) in the BBAVF group, as was the assisted primary patency rate ($p = 0.045$), whereas the secondary patency rates were comparable. The BBAVF group needed fewer interventions to prevent failure (1.7 interventions/patient/year versus 2.7 interventions/patient/year). The complication rates were low in both groups (1.6 per patient/year with BBAVF versus 2.7 per patient/year in the AVG group).

Kakkos et al. (15) similarly reported equivalent secondary patency rates of upper extremity polyurethane AVG and BBAVF. Early complications were higher in AVF, but late complications were higher in AVG. Steal and venous hypertension were higher in AVF, but thrombosis was higher in AVG. Patients with BBAVF required longer times until first cannulation (14 days for AVG versus 70 days for the BBAVF). As a likely consequence of this, central venous stenosis was found more often in patients who received BBAVF, as they required longer central venous access while awaiting maturation.

Comparison of BBAVF with BBrAVF AVF (Table 4)

The brachial artery–brachial vein (BBrAVF) has emerged as a viable option for hemodialysis recently, and its insertion into the currently accepted algorithm for fistula site placement is not clear. The Brescia-Cimino radiocephalic fistula is widely regarded as the first choice, followed by BCF, BBAVF, and finally AVG. BBrAVF is preferred by the authors prior to AVG. Both BBAVF and BBrAVF require superficialization so as to be able to cannulate the vein. In addition, the brachial vein is even more thin-walled and has many more small tributaries, making the dissection more tedious. Nevertheless, the BBrAVF may be a suitable option prior to the placement of an AVG if a BBAVF is not an option.

Casey et al. (16) compared 42 one-stage BBAVF with 13 BBrAVF and 94 AVG in a single-center retrospective study. The mean preoperative vein size was 4.9 mm in both groups. The authors noted that if both veins appeared adequate, the basilic vein was used owing to ease of mobilization and fewer branches. The primary failure rate was 26% for BBAVF and was quite high at 53% for BBrAVF. One-year primary patency was similar for BBAVF and BBrAVF at 50% and 40%, respectively ($p = 0.154$). Torina et al. found lower 1-year patency for BBrAVF of only 24%, compared to 45% for BBAVF and 50% for AVG. As may be expected, complication rates were higher for BBrAVF at 73% compared with 52% for BBAVF and 55% for AVG. Given the relative newness of BBrAVF, the low patency, and high early failure, larger randomized studies are needed to determine its precise role.

Conclusion

The vast majority of studies reporting patency rates for BBAVF are retrospective, single-center studies. True primary patency rates are difficult to calculate as many of these reports do not include primary failure rates. For those that do, the primary failure rates are as high as

40% with true primary failure likely 15–20%. The mean 1-year primary patency rate appears to be approximately 72% with a range of 23–90%. The mean 1-year secondary patency rate is slightly higher. The number of required interventions to maintain patency is lower with brachial artery–basilic vein fistula compared to AVGs.

The 2-year primary patency rates for BBAVF range from 11% to 86% and likely fall around 62%. Once they achieve maturation, BBAVF have higher patency rates, require fewer interventions, and have substantially lower risk of infection than AVG, which have statistically lower 2-year primary patency rates. However, in choosing between a BBAVF and AVG, one must also factor in whether the patient is already on dialysis, as maturation times for BBAVF are significantly longer and thus will require a significantly longer period of central venous access. In one study, a polyurethane AVG was shown to have equivalent secondary patency rates compared to BBAVF with aggressive access surveillance and endovascular interventions.

When planning a BBAVF, preoperative vein mapping is recommended. This permits determination of length of usable basilic vein and diameter prior to joining the brachial vein. It appears that the minimum diameter for successful BBAVF is 3 mm.

BBAVF can be performed as either a one-stage or two-stage procedure, with either elevation alone, anterolateral transposition via tunneling, or transposition via creation of a subcutaneous flap. Elevation alone without transposition cannot be recommended based on current evidence as it poses risks to adjacent structures during cannulation and is associated with much lower dialysis staff satisfaction. Based on limited evidence, the two-stage BBAVF may result in increased primary patency at 15 months than one-stage procedure. A lower primary failure rate may be partially responsible for the improved outcomes in the two-stage procedure. Larger, randomized studies are needed to determine conclusively whether the two-stage BBAVF results in superior patency rates compared to a one-stage operation.

The wide range of primary failure rates and patency rates may reflect surgical technique, selection bias, and variable inclusion criteria after preoperative vein mapping, reporting bias, differences in vascular biology, and other unidentified factors. Overall, the patency rate of BBAVF is comparable to other upper extremity AVF. Brachial vein to brachial artery AVF is newer technique that holds promise, but early data indicate that the patency do not approach that of other upper arm AVF.

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References

1. National Kidney Foundation: KDOQI Clinical Practice guidelines and clinical practice recommendations for vascular access. *Am J Kidney Dis* 48(Suppl 1):S176–S322, 2006
2. Dagher FJ, Gelber RL, Ramos EJ, Sadler JH: Basilic vein to brachial artery fistula: a new access for chronic hemodialysis. *South Med J* 69:1438–1440, 1976
3. Dagher F, Gelber R, Ramos E, Sadler J: The use of basilic vein and brachial artery as an A-V fistula for long term hemodialysis. *J Surg Res* 20:373–376, 1976
4. Dix FP, Khan Y, Al-Khaffaf H: The brachial artery-basilic vein arteriovenous fistula in vascular access for haemodialysis – a review paper. *Eur J Vasc Endovasc Surg* 31:70–79, 2006
5. El Mallah S: Staged basilic vein transposition for dialysis angioaccess. *Int Angiol* 17:65–68, 1998
6. Koksoy C, Demirci RK, Balci D, Solak T, Kose SK: Brachiobasilic versus brachiocephalic arteriovenous fistula: a prospective randomized study. *J Vasc Surg* 49:171.e5–177.e5, 2009
7. Tordoir JH, Dammers R, de Brauw M: Video-assisted basilic vein transposition for haemodialysis vascular access: preliminary experience with a new technique. *Nephrol Dial Transplant* 16:391–394, 2001
8. Humphries AL Jr, Colborn GL, Wynn JJ: Elevated basilic vein arteriovenous fistula. *Am J Surg* 177:489–491, 1999
9. Murphy GJ, White SA, Knight AJ, Doughman T, Nicholson ML: Long-term results of arteriovenous fistulas using transposed autologous basilic vein. *Br J Surg* 87:819–823, 2000
10. Woo K, Farber A, Doros G, Killeen K, Kohanzadeh S: Evaluation of the efficacy of the transposed upper arm arteriovenous fistula: a single institutional review of 190 basilic and cephalic vein transposition procedures. *J Vasc Surg* 46:94–99; discussion 100, 2007
11. Moossavi S, Tuttle AB, Vachharajani TJ, Plonk G, Bettmann MA, Majekodunmi O, Russell GB, Regan JD, Freedman BI: Long-term outcomes of transposed basilic vein arteriovenous fistulae. *Hemodial Int* 12:80–84, 2008
12. Hakaim AG, Nalbandian M, Scott T: Superior maturation and patency of primary brachiocephalic and transposed basilic vein arteriovenous fistulae in patients with diabetes. *J Vasc Surg* 27:154–157, 1998
13. Coburn MC, Carney WI Jr: Comparison of basilic vein and polytetrafluoroethylene for brachial arteriovenous fistula. *J Vasc Surg* 20:896–902; discussion 903–894, 1994
14. Keuter XH, De Smet AA, Kessels AG, van der Sande FM, Welten RJ, Tordoir JH: A randomized multicenter study of the outcome of brachial-basilic arteriovenous fistula and prosthetic brachial-antecubital forearm loop as vascular access for hemodialysis. *J Vasc Surg* 47:395–401, 2008
15. Kakkos SK, Andrzejewski T, Haddad JA, Haddad GK, Reddy DJ, Nypaver TJ, Scully MM, Schmid DL: Equivalent secondary patency rates of upper extremity Vectra Vascular Access Grafts and transposed brachial-basilic fistulas with aggressive access surveillance and endovascular treatment. *J Vasc Surg* 47:407–414, 2008
16. Casey K, Tonnessen BH, Mannava K, Noll R, Money SR, Sternbergh WC 3rd: Brachial versus basilic vein dialysis fistulas: a comparison of maturation and patency rates. *J Vasc Surg* 47:402–406, 2008
17. LoGerfo FW, Menzoian JO, Kumaki DJ, Idelson BA: Transposed basilic vein-brachial arteriovenous fistula. A reliable secondary-access procedure. *Arch Surg* 113:1008–1010, 1978
18. Barnett SM, Waters WC 3rd, Lowance DC, Rosenbaum BJ: The basilic vein fistula for vascular access. *Trans Am Soc Artif Intern Organs* 25:344–346, 1979
19. Dagher FJ, Gelber R, Reed W: Basilic vein to brachial artery, arteriovenous fistula for long-term hemodialysis: a five year follow-up. *Proc Clin Dial Transplant Forum* 10:126–129, 1980
20. Cantelmo NL, LoGerfo FW, Menzoian JO: Brachiobasilic and brachiocephalic fistulas as secondary angioaccess routes. *Surg Gynecol Obstet* 155:545–548, 1982
21. Koontz PG Jr, Helling TS: Subcutaneous brachial vein arteriovenous fistula for chronic hemodialysis. *World J Surg* 7:672–674, 1983
22. Dagher FJ: The upper arm AV hemoaccess: long term follow-up. *J Cardiovasc Surg (Torino)* 27:447–449, 1986
23. Davis JB Jr, Howell CG, Humphries AL Jr: Hemodialysis access: elevated basilic vein arteriovenous fistula. *J Pediatr Surg* 21:1182–1183, 1986
24. Hibberd AD: Brachiobasilic fistula with autogenous basilic vein: surgical technique and pilot study. *Aust N Z J Surg* 61:631–635, 1991
25. Hatjibaloglou A, Grekas D, Saratzis N, Megalopoulos A, Moros I, Kiskinis D, Dalainas V: Transposed basilic vein-brachial arteriovenous fistula: an alternative vascular access for hemodialysis. *Artif Organs* 16:623–625, 1992
26. Rivers SP, Scher LA, Sheehan E, Lynn R, Veith FJ: Basilic vein transposition: an underused autologous alternative to prosthetic dialysis angioaccess. *J Vasc Surg* 18:391–396, discussion 396–397, 1993
27. Elcheroth J, de Pauw L, Kinnaert P: Elbow arteriovenous fistulas for chronic haemodialysis. *Br J Surg* 81:982–984, 1994
28. Stonebridge PA, Edington D, Jenkins AM: 'Brachial/basilic vein' transposition for vascular access. *J R Coll Surg Edinb* 40:219–220, 1995
29. Butterworth PC, Doughman TM, Wheatley TJ, Nicholson ML: Arteriovenous fistula using transposed basilic vein. *Br J Surg* 85:653–654, 1998

30. Gibson KD, Gillen DL, Caps MT, Kohler TR, Sherrard DJ, Stehman-Breen CO: Vascular access survival and incidence of revisions: a comparison of prosthetic grafts, simple autogenous fistulas, and venous transposition fistulas from the United States Renal Data System Dialysis Morbidity and Mortality Study. *J Vasc Surg* 34:694–700, 2001
31. Dahduli SA, Qattan NM, Al-Kuhaymi RA, Al-Jabreen MA, Al-Khader AA: Mobilization and superficialization of basilic vein for brachio basilic fistula. *Saudi Med J* 23:1203–1205, 2002
32. Tsai YT, Lin SH, Lee GC, Huen GG, Lin YF, Tsai CS: Arteriovenous fistula using transposed basilic vein in chronic hypotensive hemodialysis patients. *Clin Nephrol* 57:376–380, 2002
33. Segal JH, Kayler LK, Henke P, Merion RM, Leavey S, Campbell DA Jr: Vascular access outcomes using the transposed basilic vein arteriovenous fistula. *Am J Kidney Dis* 42:151–157, 2003
34. Taghizadeh A, Dasgupta P, Khan MS, Taylor J, Koffman G: Long-term outcomes of brachiobasilic transposition fistula for haemodialysis. *Eur J Vasc Endovasc Surg* 26:670–672, 2003
35. Rao RK, Azin GD, Hood DB, Rowe VL, Kohl RD, Katz SG, Weaver FA: Basilic vein transposition fistula: a good option for maintaining hemodialysis access site options? *J Vasc Surg* 39:1043–1047, 2004
36. Wolford HY, Hsu J, Rhodes JM, Shortell CK, Davies MG, Bakhru A, Illig KA: Outcome after autogenous brachial-basilic upper arm transpositions in the post-National Kidney Foundation Dialysis Outcomes Quality Initiative era. *J Vasc Surg* 42:951–956, 2005
37. Harper SJ, Goncalves I, Doughman T, Nicholson ML: Arteriovenous fistula formation using transposed basilic vein: extensive single centre experience. *Eur J Vasc Endovasc Surg* 36:237–241, 2008
38. Glass C, Porter J, Singh M, Gillespie D, Young K, Illig K: A Large-Scale Study of the upper arm basilic transposition for hemodialysis. *Ann Vasc Surg* 24:85–91, 2009
39. Hossny A: Brachiobasilic arteriovenous fistula: different surgical techniques and their effects on fistula patency and dialysis-related complications. *J Vasc Surg* 37:821–826, 2003
40. Francis DM, Lu Y, Robertson AJ, Millar RJ, Amy J: Two-stage brachiobasilic arteriovenous fistula for chronic haemodialysis access. *ANZ J Surg* 77:150–155, 2007
41. Reynolds T, ???? ZM, Kim K, Lee J, Ishaque B, Dukkipati R, Kaji A, Devirgilio C: One stage versus two stage brachial artery – basilic vein fistula. *Western Vascular Access Society* Abstract, 2010
42. Matsuura JH, Rosenthal D, Clark M, Shuler FW, Kirby L, Shotwell M, Purvis J, Pallos LL: Transposed basilic vein versus polytetrafluorethylene for brachial-axillary arteriovenous fistulas. *Am J Surg* 176:219–221, 1998
43. Oliver MJ, McCann RL, Indridason OS, Butterly DW, Schwab SJ: Comparison of transposed brachiobasilic fistulas to upper arm grafts and brachiocephalic fistulas. *Kidney Int* 60:1532–1539, 2001
44. Fitzgerald JT, Schanzer A, Chin AI, McVicar JP, Perez RV, Troppmann C: Outcomes of upper arm arteriovenous fistulas for maintenance hemodialysis access. *Arch Surg* 139:201–208, 2004
45. Weale AR, Bevis P, Neary WD, Lear PA, Mitchell DC: A comparison between transposed brachiobasilic arteriovenous fistulas and prosthetic brachioaxillary access grafts for vascular access for hemodialysis. *J Vasc Surg* 46:997–1004, 2007
46. Torina PJ, Westheimer EF, Schanzer HR: Brachial vein transposition arteriovenous fistula: is it an acceptable option for chronic dialysis vascular access? *J Vasc Access* 9:39–44, 2008
47. Pflederer TA, Kwok S, Ketel BL, Pilgram T: A comparison of transposed brachiobasilic fistulae with nontransposed fistulae and grafts in the Fistula First era. *Semin Dial* 21:357–363, 2008
48. Chemla ES, Morsy MA: Is basilic vein transposition a real alternative to an arteriovenous bypass graft? A prospective study *Semin Dial* 21:352–356, 2008
49. Maya ID, O'Neal JC, Young CJ, Barker-Finkel J, Allon M: Outcomes of brachiocephalic fistulas, transposed brachiobasilic fistulas, and upper arm grafts. *Clin J Am Soc Nephrol* 4:86–92, 2009