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Review Article

Transposed Brachial–Basilic Arteriovenous Fistula for Vascular Access in Japan

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As more than 320,000 patients are currently receiving hemodialysis treatment in Japan, the creation and maintenance of hemodialysis access is a major concern. The national guidelines recommend autogenous arteriovenous hemodialysis, and the brachial–basilic arteriovenous fistula has been the focus of attention, because the need for secondary, tertiary, or even more vascular access is growing. Although favorable results have been reported in terms of patency and access-related complication, this fistula involves various unsolved or controversial issues, with limitations including complex procedures, which might contribute to the lower prevalence at this point in Japan. This review addresses those issues and discusses the role of fistula in Japan.

Keywords: arteriovenous fistula, basilic vein, vascular access

Introduction

The number of patients with end-stage renal disease (ESRD) dependent on intermittent hemodialysis has exceeded 320,000 and is still increasing in Japan.[1] The development of hemodialysis has improved the long-term survival of patients and has increased availability of dialysis, including to older or diabetic individuals who have poor autogenous vessels.[2] The need for secondary, tertiary, or even more vascular access is thus growing. Because autogenous arteriovenous fistulas (AVFs) offer better patency rates with fewer complications and lower mortality rates compared with other options for vascular access, including prosthetic grafts (arteriovenous graft; AVG) or catheters,[2–4] a structured approach to optimize the use of autogenous veins in the upper limbs seems imperative for vascular access.[5]

Transposed brachiobasilic arteriovenous fistula (TBB-AVF) was introduced by Dagher in 1986[6] and has shown many favorable results in terms of patency and access-related complication.[7–9] Anatomically, the basilic vein is usually longer and has thicker wall than the cephalic vein.[10,11] This vessel is also relatively preserved from repeated cannulation of blood draws and intravenous catheter. Despite those theoretical advantages, the basilic vein needs to be translocated for cannulation in chronic hemodialysis therapy. On the other hand, AVF using the transposed basilic vein involves various unsolved or controversial issues regarding indication of staged operation, means of elevation, and timing of creation compared with the fistula using a prosthetic graft.[12–14] Moreover, the transposed fistula has some limitations, including complex procedures, longer maturation time for cannulation and non-enthusiastic recommendation in the Japanese guideline for vascular access,[15] which might be causes of the lower prevalent at this point in Japan.

The purpose of this study was to address the issues and controversies surrounding TBBAVF and to discuss its potential role for creation and management of vascular access in Japan.

Use of Vascular Access in Japan

Annual reports from the United States Renal Data System indicated that the number of treated cases of ESRD in Japan in 2014 was 2,505 per million population (3,287 in men and 1,764 in women), making Japan the country with the second highest prevalence.[16] For the record, 96.9% of the Japanese dialysis patients selected hemodialysis as a renal replacement therapy, and only approximately 1,500 renal transplantations are performed annually in Japan.[17] The mean survival time of Japanese patients after first-ever hemodialysis is 7.3 years, one of the longest in the world.[1] Patients with hemodialysis for more than 10 years account for up to 27.8%, and those with long-term hemodialysis are increasing in number, whereas patients

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with hemodialysis therapy for 5 years or less account for 47.3% of all the hemodialysis population in Japan.[1] At the same time, Japanese hemodialysis patients tend to be older and show a stronger association with diabetes, with the average age of 67.2 years and 37.6% of all hemodialysis with diabetes in 2013.[1] AVFs are recognized as a better choice for most hemodialysis patients compared with prosthetic implants such as artificial grafts or central venous catheters (CVCs)[4,18] because of complications including infection. Therefore, it is worthy of special mention that Japan showed one of the highest rates of AVF use, in more than 90% of hemodialysis patients, according to the Dialysis Outcomes and Practice Patterns Study from the United States.[19] Moreover, along with 9% using artificial graft (AVG), the most notable feature was that less than 1% of the patients were undergoing dialysis with CVC in Japan.[19] In addition, among incident first-ever hemodialysis patients, AVF use in Japan is also one of the highest rates in the world, with more than 80% using AVF, comparing 65% in Germany and 38% in the United States.[19] These results indicate that continuing efforts by Japan dialysis units are avoiding CVC and optimizing vascular access use from first-ever hemodialysis treatment.[20] Despite such efforts, development of AVF as a vascular access still faces a hostile situation in Japan, because a substantial proportion of patients lack good superficial vessels, and such patients are increasing along with increases in elderly and diabetes patients.[21]

Anatomy of the Basilic Vein

The basilic vein, originating on the medial side of dorsal venous network, runs along the medial aspect of the forearm and connects with the medial cubical vein in the elbow. This vessel runs up the ulnar aspect of the upper arm and pierces into the brachial fascia to connect with the brachial vein to form the axillary vein. In the upper arm, the basilic vein runs along with the medial antebrachial cutaneous nerve. However, several variations in basilic vein anatomy exist. Anaya-Ayala et al. described three types of brachial–basilic vein connections based on ultrasound scanning: type 1 (66%), basilic–brachial junction at the axillary level; type 2 (17%), basilic–brachial junction at the mid or lower portion of the upper arm with the duplication of the brachial vein; and type 3 (17%), basilic–brachial junction at the mid or lower portion of the upper arm with no duplication of the brachial vein.[22] Hyland analyzed basilic–brachial vein using preoperative venography for vascular access and reported early basilic–brachial vein confluence in 44% and multi-junctions of basilic–brachial vein in 7%.[23] Simply put, more than one-third of the upper limbs show a low junction of basilic–brachial confluence.

Preoperative Evaluation

Preoperative imaging by ultrasound improves the outcomes of AVF creation.[24,25] Such evaluations should include the veins and arteries throughout the forearm and upper arm, with assessment of their diameter and quality. Although vein diameter over 2.5 mm has been recommended for AVF maturation,[26] some authors favor vein diameter over 3.0 mm for TBBAVF[27,28] because the basilic vein needs to be mobilized with discission of all tributaries, which results in increasing peripheral resistance. The diameter of the brachial artery should be over 2.0 mm without a reduced pressure gradient or Doppler waveform that would suggest arterial inflow stenosis. These assessments would help identify anatomical variations of the arteries and veins.

Surgical Technique

Although Hossny classified the techniques in creating brachiobasilic AVF into three types (one-stage transposition, one-stage elevation, and two-stage elevation),[29] these procedures accepted regarding creating TBBAVF along with various technical modifications; one-stage transposition, one-stage elevation, two-stage transposition, or two-stage elevation procedures (**Fig. 1**).

One-stage procedure: This procedure is an original method for TBBAVF, comprising arteriovenous anastomosis and anterior and superficial relocation of the basilic vein.[6] Under an interscalene nerve block with or without intravenous sedation, the basilic vein is exposed from the ulnar aspect of the forearm to the axilla with a continuous or interrupted longitudinal incision. All branches of the basilic vein should be ligated and mobilized proximally to the confluence with the brachial vein. The axillary vein at the confluence should also be mobilized to facilitate the smooth transposition of the basilic vein. The antebrachial subcutaneous nerve, running along with the basilic vein in the upper arm, is carefully spared. The basilic vein is gently distended with heparinized saline to eliminate distortion. The brachial artery is then explored at the elbow. The mobilized basilic vein is transposed to the anterior arm inside a subcutaneous pocket by direct dissection (transposition). Korkut and Kosem recently described transposition of mobilized basilic vein with the use of tunneling device under separate skin incision.[30] Although transposition is a common way of superficial relocation, a few groups prefer primary elevation for TBBAVF, simply comprising mobilization of basilic vein superficially (elevation).[31,32] In their opinion, elevation may reduce the risk of kinking or twisting of the fistula. Special attention should be paid to ensure that the vein shows a smooth curve near the axilla without twisting. After systemic

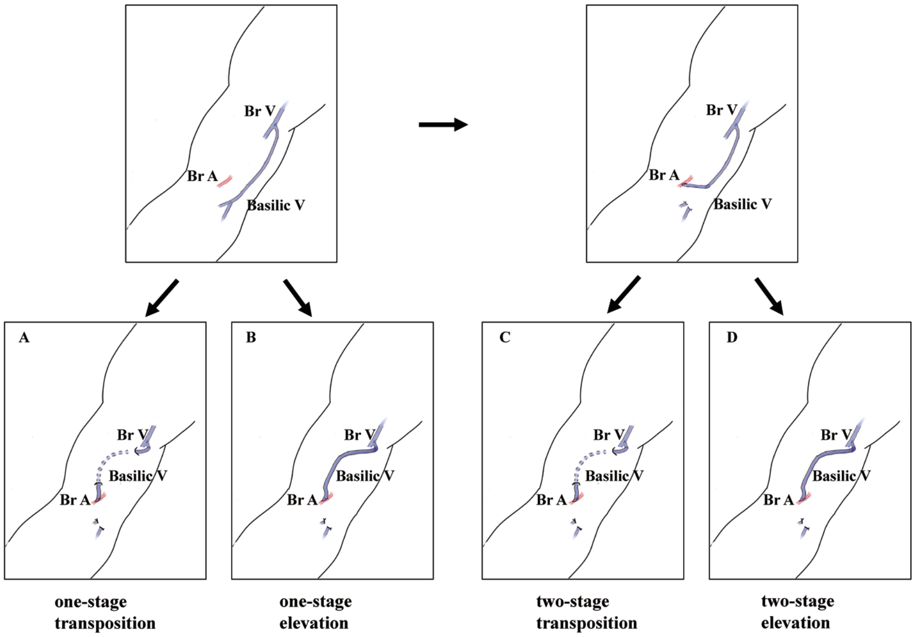

Fig. 1 Schema of types of TBBAVF. One-stage procedure comprises arteriovenous anastomosis and anterior and superficial relocation of the basilic vein in one operation. Two-stage procedure is a creation of arteriovenous fistula followed by relocation of the basilic vein at different times. Transposition is a relocation with tunneling using tunneler device and elevation indicates moving superficially without tunneling. (**A**) one-stage transposition; (**B**) one-stage elevation; (**C**) two-stage transposition; (**D**) two-stage elevation.

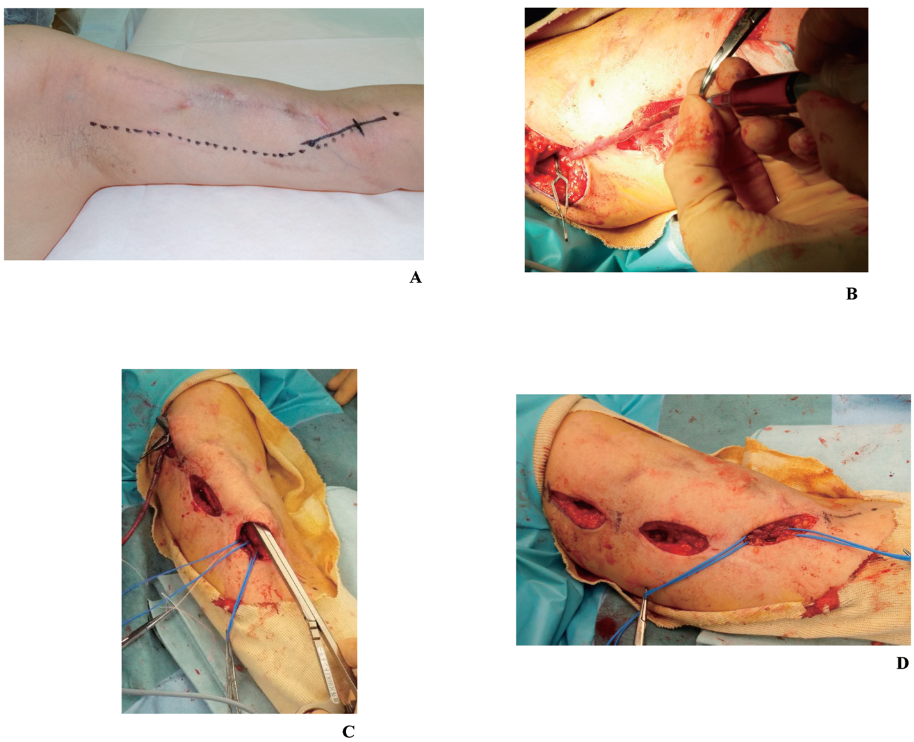

Fig. 2 Illustration of surgical procedure of one-stage transposition. (**A**) preoperative marking; (**B**) distention of the basilic vein with heparinized saline to eliminate distortion; (**C**) tunneling of mobilized basilic vein; (**D**) completion of anastomosis between the transposed basilic vein and the brachial artery.

anticoagulation with heparin sulfate, a vascular clamp is made with a 5 mm arteriotomy in the brachial artery and an end-to-side anastomosis is constructed using a 6-0 or 7-0 polypropylene suture. The course of the vein should be examined closely, and the presence of a thrill is a key to creating successful fistula (**Fig. 2**).

Two-stage procedure: The first stage of this procedure is simply the creation of the AVF, followed by the second stage of elevation or transposition.[33,34] The first stage includes an end-to-side anastomosis between the basilic vein and the brachial artery in the elbow. Several weeks later, at the time of the basilic vein maturation, the basilic vein is mobilized from the previous anastomosis site to the confluence with the brachial vein through continuous or interrupt longitudinal incision. The two-stage method may facilitate placement of pressure on smaller ramifications and reduce the risk of surgical flaw at the time of mobilization. With the creation of a pocket in the subcutaneous tissue, the basilic vein is relocated superficially and anterolaterally for "elevation,"[35] or the fistula vein is transected, then routed via the superficial tunnel anterolaterally and re-anastomosed, representing "transposition" instead of simple elevation. Although elevation and transposition are confused in some reports, transposition method seems to be more prevalent because denuded area can be reduced in the second stage. Wang et al. recently compared two-stage elevation with two-stage transposition and found that two-stage elevation is a reliable approach because of better primary patency and reduced need for salvage interventions to the fistulas.[36] The interval between the first and second operations is varied from 3 to 8 weeks depending on the maturation criteria of the basilic vein.

Other techniques: Several surgical modifications have been described, usually comprising reduced tissue dissection to avoid skin complications.[37–40] Using endoscopic vein-harvesting system with sealing and division of the branches of the basilic vein, several small incision techniques offer comparable results with those of the regular open method.

Criteria of Maturation

Without standard criteria for fistula maturation, there are no specific criteria of maturation for TBBAVF. In Japan, early cannulation tends to be performed with a minimal access flow rate of 160 mL/min for radial–cephalic AVF, compared with 200 mL/min in Europe and 300 mL/min in the United States. According to the KDOQI 2006 guidelines, functional access can be defined for fistula diameter >6 mm, access flow >600 mL/min and the depth <6 mm.[18] Arroyo et al. described the following criteria for maturation in TBBAVF: fistula vein diameter >6 mm, estimated access flow >400 mL/min without stenosis.[41] Lioupis' criteria were fistula vein diameter >3.5 mm and access flow >600 mL/min.[42] Because Voormolen et al. identified immature AVF as providing insufficient access flow at 6 weeks after creation[43] and the vascular access guideline in Japan showed below 200 mL/min of access flow as insufficient flow, more than 300 mL/min of access flow 6 weeks after creation would be minimum for TBBAVF. Rao et al. reported a high failure rate for maturation in TBBAVF, up to 38%.[44] However, other reports have usually described lower maturation around 10–20%. Hakaim et al. compared radiocephalic, brachiocephalic, and TBBAVFs, reporting superior maturation of TBBAVF in diabetic patients.[45]

TBBAVF vs. AVG

Several reports have compared TBBAVF with prosthetic vascular access. As fistulas using prosthetic graft (AVG) show wide variation, including brachial–antecubital forearm loop or brachial–axial straight with several prosthetic graft materials, methods should be tested one by one when comparing between TBBAVF and AVG in each manuscript. **Table 1** summarizes the main outcomes reported in various studies.[42,46–62] Chemla and Morsy found that TBBAVF offered a better patency rate with greater cost-effectiveness compared with brachio-axillary AVG.[53] Chue et al. studied 122 Asian patients and reported that TBBAVF provided superior patency and required fewer salvage interventions compared with forearm AVG.[62] However, recent studies showed comparable patency between AVG and TBBAVF and have favored the use of prosthetic grafts in specific groups like elderly patients, because of the short cannulation period.[42,55,61] Overall, utilization of TBBAVF is associated with reduced risk of access failure, whereas AVG represents the preferred option for elderly patients.[63]

One-Stage vs. Two-Stage Approach

The choice between one- and two-stage approaches has been a subject of focus in creating TBBAVF. To date, two randomized reports have compared one- and two-stage procedures, showing higher maturation and better 1 year patency in the two-stage procedure.[64,65] However, both studies have critical limitations, including small sample size (n=16) in the study by Kakkos et al.[65] and short follow-up period in El Mallah's study,[64] with considerable disparity in maturation rate and patency compared with their former report.[65,66] Data on the features of one- or two-stage procedures of TBBAVF have been accumulated from several retrospective studies.[67] Mixed opinions have been reported regarding functional patency rate, with some studies describing better patency rates under the

Table 1 List of studies compared TBBAVF with AVG

First author	Year	Study		Number of patients	Patency at 1 year (primary/ secondary)	Patency at 2 years (primary/ secondary)	Type of prosthesis	Main complications	Comment
Coburn	1994	Retrospective	TBBAVF	59	90*	86*		Infection 3.4%, bleeding 6.8%	
			AVG	47	70/87	49/64	PTFE	Infection 16.1%, bleeding 1.6%	
Matsuura	1998	Retrospective	TBBAVF	30		70		Infection 0%	
			AVG	67		46	Brachio-axillary, PTFE	Infection 10%	
Gibson	2001	Retrospective	TBBAVF	181		27.7/61.5			Benefit for women and patients with access failure
			AVG	64		24.6/39.8			
Oliver	2001	Retrospective	TBBAVF	59	/64			Infection 2%, poor maturation 6%, arm swelling 3%	
			AVG	82	/62		PTFE	Infection 13%, poor maturation 1%, arm swelling 6%	
Weale	2007	Retrospective	TBBAVF	71	45.3/53.6	40.0/50.9		Infection 0%	
			AVG	114	56.4*	43.2*	Brachio-axillary	Infection 6.2%	
Kakkos	2008	Controlled comparative	TBBAVF	76	46/87 (primary assist, 82%)			Infection 0%, bleeding 9.8%, venous hypertension 15%	
			AVG	41	50/88 (primary assist, 70%)		Brachio-axillary, Vectra	Infection 6.6%, bleeding 2.6%, venous hypertension 1.3%	
Keuter	2008	Randomized	TBBAVF	52	46/89 (primary assist, 87%)			Incidence rate of complications: 1.6 per patient-year	
			AVG	53	22/85 (primary assist, 71%)		Forearm loop, PTFE	Incidence rate of complications: 2.7 per patient-year	
Chemla	2008	Retrospective	TBBAVF	34	73/93	69/85			TBBAVF: cost-effective
			AVG	42	61/70	54/62	Brachio-axillary, PTFE (Intering)		
Pflederer	2008	Retrospective	TBBAVF	161	58/97	44/97		Infection rate: 0.07 per patient-year	
			AVG	285	18/66	5/54	Loop, straight	Infection rate: 0.23 per patient-year	
Torina	2008	Retrospective	TBBAVF	42	45/74 (primary assist, 74%)**				
			AVG	94	50/78 (primary assist, 63%)				
Maya	2009	Prospective	TBBAVF	67		/55		Primary access failure: 15%	
			AVG	289		/45		Primary access failure: 18%	
Woo	2009	Retrospective	TBBAVF	119	65*			Infection 1.6%, bleeding 3.7%, steal 3.2%	
			AVG	168	48*		Upper arm, PTFE	Infection 7.9%, bleeding 1.8%, steal 4.9%	
Sala Almonacil	2011	Retrospective	TBBAVF	36	50.4/50.4	45.8/45.8		Infection 0%, access problem 13.8%	
			AVG	40	64.3/67.7	46.2/54.2	Brachio-axillary, PTFE	Infection 10%, access problem 5%	
Lioupis	2011	Retrospective	TBBAVF	45		51***			Access intervention: higher in AVG group
			AVG	48		55***	Brachio-axillary, PTFE (Flixene)		

Table 1 Continued

First author	Year	Study		Number of patients	Patency at 1 year (primary/ secondary)	Patency at 2 years (primary/ secondary)	Type of prosthesis	Main complications	Comment
Morosetti	2011	Retrospective	TBBAVF	30	61/76	60/66			
			AVG	27	32/52	21/34	Polyester Omniflow		
Basel	2011	Retrospective	TBBAVF			67			
			AVG			32			
Davoudi	2013	Randomized	TBBAVF	30	76.3			Similar thrombosis or infection rate	
			AVG	30	70		Brachio-axillary		
Chue	2016	Retrospective	TBBAVF		73.2/71.8				
			AVG		34.1/54.3		Forearm loop, PTFE		

*: secondary not described; **: two-stage procedure; ***: secondary patency at 18 months

two-stage approach and some showing comparable patency rates in both groups.[66,68,69] Vrakas et al. reported better 2 year primary and secondary patency rates of 75% and 77% for two-stage approach, respectively, compared with those of 53% and 57% for one-stage approach.[70] Ozcan et al. found that those two approaches offered similar patency and a higher complication rate in one-stage approach including thrombosis and hematoma.[68] Bashar et al. conducted a systematic review and meta-analysis for eight manuscripts covering 859 fistulas, concluding that the differences between one- and two-stage procedures were not statistically significant in terms of overall maturation rate or postoperative complication, with comparable patency rates.[71] However, recent reports have indicated better patency with the two-step method, and Mauro et al. found that transecting the basilic vein at the anastomosis and tunneling it superficially led to fewer complications and easier cannulation than elevating the basilic artery in the two-stage procedure.[72] In general, reports overall showed that the rate of fistula maturation was higher, but the time to cannulation was longer in the two-stage procedure.[65,68,69] Even so, an assessment by Ghaffarian et al. revealed that two-stage procedure was cost-effective with higher patency and lower rates of failure.[73] **Table 2** showed the summary of main studies so far.[29,64–66,68–70,73–75]

Complications

No specific postoperative complications are associated with TBBAVF.[14] However, the incidence of complications such as arm edema and access-related bleeding seems higher than with other vascular access, attributable to the extensive surgical mobilization and cannulation in the early period. Woo et al. reported that the incidence of infectious complications was much lower for TBBAVF, at around 2%, compared with 8% with AVG.[76] Beaulieu et al. noted that the most common complication of TBBAVF in the long-term period was stenosis, and the site of stenosis was commonly the confluence of transposition of the basilic vein to the brachial vein.[77] Intervention for such stenosis appears effective, although repeated intervention may be necessary.

TBBAVF in Japan

Japan has shown one of the highest AVF use, in more than 90% of the hemodialysis patients. Radiocephalic AVF followed by brachiocephalic AVF is usually created when the superficial cephalic vein is available. AVG is usually the next option, and TBBAVF is not at all common in Japan. Because the KDOQI Clinical Practice Guidelines for Vascular Access place TBBAVF prior to AVG in the order for fistula placement and suitable basilic vein are left unused in many Japanese patients, creation of TBBAVF should be an option before AVG for many Japanese patients. However, considering the low maturation rate and longer time required for cannulation, TBBAVF may be a tertiary or subsequent fistula even in Japan. We found that TBBAVF might achieve maturation for cannulation when the basilic vein is identified as $\geq$3 mm in diameter preoperatively. The long time until cannulation may cost patients with CVC catheter for a couple of months. Therefore, a one-step approach of TBBAVF rather than a two-step approach may be favorable to reduce catheter time in Japan, although further study is clearly needed. We reported some of TBBAVF with one-step procedure can be used 2 weeks after creation when the fistulas showed good thrill,[78] which would be one solution for reduced time for cannulation. One opinion is that the forearm loop AVG is a better option than TBBAVF because the stenosis of confluent site at the basilic vein in TBBAVF ruins the choice of

Table 2 List of main studies compared between one-stage and two-stage procedures in TBBAVF

Authors	Year	Study type	Number	Maturation rate (%)		Secondary patency at 2 years		Complication	Recommendation
				One stage	Two stage	One stage	Two stage		
El Mallah	1998	Randomized	One stage 20 Two stage 20	60	90				Two stage
Hossny	2003	Retrospective	One-stage transposition 40 One-stage elevation 20 Two-stage elevation 20			Transposition 82.8 Elevation 70	Elevation 68.4	Hematoma: 26.3% in elevation group	
Kakkos	2010	Retrospective	One-stage transposition 76 Two-stage transposition 98 (72)*	85**	82**			Complications: higher in one-stage method 10 in two-stage group did not attain second stage	Two stage
Reynolds	2011	Retrospective	One-stage transposition 60 Two-stage tansposition 30	77.1	90.9	41	94	30 days complications: similar in both groups	Two stage
Syed	2012	Retrospective		79	82	81	27		
Vrakas	2013	Retrospective	One-stage transposition 65 Two-stage elevation 84	55	58	57	77	Complications: similar in both groups	Two stage
Ozcan	2013	Retrospective	One stage 47 (basilic vein >3 mm) Two stage 59 (basilic vein <3 mm)	66	77	98	98	Complications: higher in one-stage method	Two stage
Robertson	2013	Retrospective	One stage 29 Two stage 44	76	84	86.2***	91.6***		One stage
Agarwal	2014	Retrospective	One stage 61 Two stage 83	90	75	75	71	Required interventions: similar in both groups	
Kakkos	2015	Randomized	One-stage transposition 9 Two-stage transposition 7	33	100	44	86		Two stage
Ghaffarian	2017	Retrospective	One stage 57 Two stage 74			44	73	Complications: similar in both groups Two stage was durable and cost-effective	Two stage

*: 72 out of 98 underwent a second-stage operation; **: including lost or refuse patients; ***: secondary patency at 6 months

forearm loop AVG. However, it is important to remember that forearm loop AVG shows critical complications such as infection. Even if forearm loop AVG does represent a useful alternative to TBBAVF, the basilic vein should be carefully preserved for a backup fistula.

Conclusion

TBBAVF offers a valuable autogenous vascular access and represents a good alternative after radial–cephalic and brachial–cephalic configuration. Issues remain regarding TBBAVF, including selection of a one- or two-stage approach, superiority over new artificial graft, and indications for hostile vascular access patients such as those with older age or diabetes, but TBBAVF represents the essential option for a structured approach to optimize autogenous veins for vascular access.

Disclosure Statement

The authors have neither financial nor other potential conflict to declare.

Author Contributions

Study conception: JD, OS
Writing: JD
Funding acquisition: OS
Critical review and revision: JD, OS
Final approval of the article: JD, OS
Accountability for all aspects of the work: JD, OS

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