

Original Article

Review of Patency Rates between One-Stage and Two-Stage Brachial-Basilic Transposition Arteriovenous Fistulae Creation in an Asian Population

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Objective: To compare patency rates between one- and two-stage (first-stage arteriovenous anastomosis followed by second-stage superficialization) creation of brachial-basilic transposition arteriovenous fistula (BBT-AVF) in an Asian population.

Methods: A retrospective review of BBT-AVFs was conducted between July 2008 and March 2015. Kaplan–Meier survival analysis and log-rank test were used to evaluate patency.

Results: In total, 103 BBT-AVFs were created in 86 patients (mean age, 61 years; men, 57%). The overall primary, assisted primary, and secondary patency rates at 12, 24, 36, and 48 months were 70%, 48%, 38%, and 35%; 86%, 70%, 62%, and 59%; and 90%, 77%, 70%, and 63%, respectively. There was no significant difference in demographics and preoperative vessel caliber between the groups. The primary failure rate was 24% in the one-stage group, compared with 21% in the two-stage group ($p=0.803$). There were no statistically significant differences in primary, assisted primary, and secondary patency rates between the groups.

Conclusion: There was no significant difference in primary failure and patency rates between the two groups. Both one-stage and two-stage procedures conferred good out-

comes with overall 12-month primary patency, secondary patency, and primary failure rates of 70%, 90%, and 23%, respectively.

Keywords: BBT-AVF, one-stage, two-stage, patency rates, Asian population

Introduction

As recommended in the 2006 Kidney Disease Outcome Quality Initiative Clinical Practice Guidelines,^{1,2)} arteriovenous fistula (AVF) is superior to both arteriovenous graft and central venous catheter in patients requiring long-term hemodialysis. The principle in deciding the location for an AVF, in general, is to first attempt on the non-dominant hand before proceeding to the dominant hand; from distal to proximal; and from radiocephalic (RC) to brachiocephalic (BC) to brachio-basilic transposition (BBT).

BBT-AVF, since its first description in 1976 by Dagher et al.,³⁾ has been an important alternative for patients who have exhausted all possibilities for RC and BC AVFs in both arms. Two major surgical approaches have been described: one-stage and two-stage BBT-AVF creations.^{4,5)} The one-stage procedure involves dissecting and mobilizing the basilic vein, and transposing into the superficial subcutaneous layer before anastomosing it to the brachial artery—all in one sitting. The two-stage procedure, on the contrary, only creates the brachio-basilic anastomosis during the first stage, followed by subsequent dissection, mobilization, and transposition of the well-arterialized basilic vein to a more superficial plane at a later date (second stage). The one-stage approach offers benefits of reduced total cost, shorter operation-to-cannulation time, and less exposure to perioperative risks. By contrast, the two-stage approach offers benefits of easier mobilization of the arterialized basilic vein and interval selection of

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patients on whether to proceed to second stage (hence, filtering out unsuitable candidates from being subjected to a potentially unnecessary extensive mobilization and larger postoperative wound). Because most data on BBT-AVF patency rates have been derived from Western and Middle Eastern centers, we aimed to compare the patency rates between the one-stage and two-stage procedures in an Asian population.

Methods

Data collection

This was a single-center retrospective study conducted on patients who underwent BBT-AVF creation between July 2008 and March 2015 at a 1,500-bed university tertiary hospital. The decision to proceed with one-stage or two-stage BBT-AVF creation was made after considering clinical factors, patient expectations, and surgeon preference. Clinical factors contributing to decision making included vessel caliber, premorbid status and comorbidities, and anesthetic risks. Patients who underwent one-stage BBT-AVF creation were reviewed at the clinic after 6 weeks to arrange for a trial of cannulation if AVF maturation was uneventful. By contrast, patients who underwent two-stage BBT-AVF creation generally needed at least 12 weeks before getting AVF ready for use. They were reviewed firstly at 6 weeks after the operation to assess maturation and arrange for the second-stage superficialization within 2 weeks, according to the availability of operation slot. Meanwhile, another 4 weeks were allowed for wound healing before cannulation. In case of complicated maturation, or failure in dialysis, duplex ultrasonography and fistuloplasty/stenting/surgical revision were used to improve maturation or restore patency. Demographic and clinical data, AVF characteristics, and outcome data of the patients were retrieved and analyzed. Demographic and clinical data such as body mass index (BMI), American Society of Anesthesiologists (ASA) score, comorbidities, antiplatelet therapy, and preoperative ultrasound vessel caliber were included for analysis. AVF specifics including operation date, complications, trial of cannulation outcome, salvage intervention and date (including fistuloplasty, thrombolysis, thrombectomy, or surgical ligation/revision) were collected. As per consensus within the literature, patency definitions are as follows⁶:

- **Primary patency:** This is the interval from the time of AVF creation until: (i) any intervention performed to maintain or reestablish patency; (ii) AVF thrombosis; or (iii) the time of patency measurement.
- **Assisted primary patency:** This is the interval from the time of AVF creation until: (i) AVF thrombosis or (ii) the time of patency measurement. The assisted primary patency interval includes intervening manipulations (sur-

gical or endovascular interventions) designed to maintain the functionality of a patent access.

• **Secondary patency:** This is the interval from the time of AVF creation until: (i) AVF abandonment or (ii) the time of patency measurement. The secondary patency interval includes all intervening manipulations (surgical or endovascular interventions) designed to maintain the functionality of a patent access and to reestablish functionality of a thrombosed AVF.

Statistical analysis

Categorical data were described as numbers, ratios, and percentages, whereas numerical data were described as mean, range, and standard deviation (SD). Considering the purpose of the current study, patients were categorized into two groups: one-stage BBT-AVF creation group and two-stage BBT-AVF creation group. Categorical data were compared using Fisher exact/Chi-square test, whereas numerical data were compared using t-test. Statistical significance was set at $p < 0.05$.

Primary, assisted primary, and secondary patency rates of one-stage and two-stage BBT-AVF creation at 12, 24, 36, 48 months were calculated using Kaplan–Meier survival analysis and compared using log-rank test. The statistical analyses were performed using SPSS version 24.0.

Results

In total, 103 BBT-AVFs were created in 86 patients (mean age, 61 years; men, 57%) from July 2008 to March 2015, with a mean follow-up duration of 34 months [range,

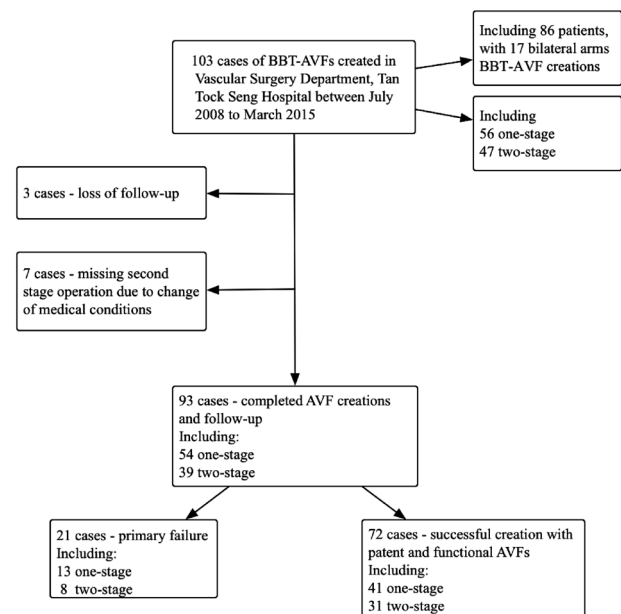


Fig. 1 BBT-AVF study flowchart.

BBT-AVF: brachiobasilic transposition arteriovenous fistula

1–92; SD, 24; 95% confidence interval (CI) 28–39]. The mean BMI was 25.2 (range, 17.6–44.7; SD, 5.45) kg/m². Most (95%) patients had hemodialysis commenced at the time of BBT-AVF creation, and 87% had tunneled dialysis catheter (TDC) in situ, of whom 26% had their BBT-AVFs created ipsilateral to their TDC, and 20% underwent BBT-AVF creation in both arms. Three patients (3%) were lost to follow-up: 2 patients from the one-stage group and 1 patient from the two-stage group. Within the two-stage group, 7 patients (15%) did not complete the second-stage superficialization due to changes in their medical conditions. A total of 93 BBT-AVFs were created and followed up in our center during our study period, with 54 one-stage and 39 two-stage procedures (Fig. 1).

Between the one-stage and two-stage groups, there was no significant difference in patient demographics, baseline characteristics, and preoperative vessel caliber (Table 1). There were also no statistically significant differences in early postoperative complications, including wound infection, hematoma, steal syndrome, venous hypertension, and neuropathy (Table 1). The mean medical cost of one-stage and two-stage BBT-AVF creations was Singapore dollars (SGD) 1,245 (range, 672–1,732; SD, 535) and SGD 2,402 (range, 1,951–3,220; SD, 565), respectively ($p < 0.001$).

A total of 21 BBT-AVF creations failed primarily, meaning they failed to mature into functional AVF, with an overall primary failure rate of 23%. Primary failure in the one-stage group was 24% (13/54 patients), as compared

Table 1 Comparison of patient demographics, clinical data, and complications in one-stage and two-stage BBT-AVF creation groups

	One-stage (n=56, 54%)	Two-stage (n=47, 46%)	p value
Male : female	30 (46) : 26 (54)	30 (36) : 17 (64)	0.322
Chinese : Malay : Indian	41 : 15 : 0	32 : 12 : 3	0.158
Mean age in years (range, SD)	58.8 (37–79, 9.9)	63.0 (31–87, 13.3)	0.069
ASA2 : ASA3 : ASA4	5 : 46 : 5	9 : 32 : 6	0.225
Mean BMI in kg/m ² (range, SD)	24.7 (20.0–39.6, 4.3)	25.7 (17.6–41.4, 5.9)	0.403
Smoker	13 (23)	11 (23)	1.000
Comorbidities			
Type 2 diabetes mellitus	36 (64)	30 (64)	1.000
Hyperlipidemia	45 (80)	37 (79)	1.000
Hypertension	49 (88)	42 (89)	1.000
Ischemic heart disease	28 (50)	26 (55)	0.693
Previous stroke	10 (18)	6 (13)	0.589
Peripheral vascular disease	11 (20)	9 (19)	1.000
Dermatological diseases	0 (0)	3 (6)	0.092
Previous renal access			
TDC in situ	52 (93)	38 (81)	0.081
TDC ipsilateral as BBT-AVF	14 (25)	13 (28)	0.492
Ipsilateral RC-AVF	16 (29)	14 (30)	1.000
Ipsilateral BC-AVF	27 (48)	13 (28)	0.043
Central vein stenosis	6 (11)	6 (13)	0.767
Medications			
Aspirin	18 (32)	21 (45)	0.224
Clopidogrel	10 (18)	6 (13)	0.589
Anti-coagulation	27 (48)	26 (55)	0.554
Pre-operative vessel size (mm)			
Brachial artery (mean, range)	3.9, 3.0–4.8	4.0, 3.2–5.7	0.821
Basilic vein (mean, range)	4.3, 2.6–6.0	4.1, 1.6–7.2	0.914
Complications			
Wound infection	4 (7)	5 (11)	0.729
Hematoma	9 (16)	5 (11)	0.566
Steal syndrome	3 (5)	2 (4)	1.000
Venous hypertension	2 (4)	2 (4)	1.000
Neuropathy	2 (4)	2 (4)	1.000
Mean medical costs in SGD (range, SD)	1,245 (672–1,732, 535)	2,402 (1,951–3,220, 565)	<0.001

ASA: American Society of Anesthesiologists physical status classification system; BBT-AVF: brachio-basilic transposition arteriovenous fistula; BC-AVF: brachio-basilic arteriovenous fistula; BMI: body mass index; RC-AVF: radiocephalic arteriovenous fistula; SD: standard deviation; SGD: Singapore dollars; TDC: tunneled dialysis catheter

to 21% (8/39 patients) in the two-stage group. There was no statistically significant difference in primary failure rates between the two groups ($p=0.803$) (Table 2).

The overall primary, assisted primary, secondary patency rates were 70%, 48%, 38%, and 35%; 86%, 70%, 62%, and 59%; and 90%, 77%, 70%, and 63% at 12, 24, 36, and 48 months, respectively (Fig. 2A).

Primary, assisted primary, and secondary patency rates of one-stage and two-stage BBT-AVF creation at 12, 24, 36, 48 months were calculated using Kaplan–Meier survival analysis and compared using log-rank test, which showed no statistically significant difference between the two groups (Figs. 2B–2D). Primary patency rates of one-stage BBT-AVF creation were 70%, 51%, 42%, and 39%

at 12, 24, 36, and 48 months, respectively, whereas the primary patency rates of two-stage BBT-AVF creation were 69%, 43%, 29%, and 29% at 12, 24, 36, and 48 months, respectively ($p=0.639$). Assisted primary patency rates of one-stage BBT-AVF creation were 80%, 70%, 63%, and 60% at 12, 24, 36, and 48 months, respectively, whereas assisted primary patency rates of two-stage BBT-AVF creation were 93%, 70%, 56%, and 56% at 12, 24, 36, and 48 months, respectively ($p=0.982$). Secondary patency rates of one-stage BBT-AVF creation were 88%, 80%, 73%, and 65% at 12, 24, 36, and 48 months, respectively, whereas secondary patency rates of two-stage group were 93%, 73%, 59%, and 59% at 12, 24, 36, and 48 months, respectively ($p=0.498$).

Table 2 Comparison of primary failure rates between one-stage and two-stage BBT-AVFs

	Non-primary failure	Primary failure	Primary failure rate (%) ($p=0.803$)
One-stage (n=54)	41	13	24
Two-stage (n=39)	31	8	21

BBT-AVF: brachiobasilic transposition arteriovenous fistula

Discussion

Our study is the largest Asian series comparing BBT-AVF creation between one-stage and two-stage procedures. Most published studies are retrospective in nature and generally limited to Western or Middle Eastern centers. To date, there are only 2 randomized controlled trials (RCTs) published. The first RCT with a follow-up period

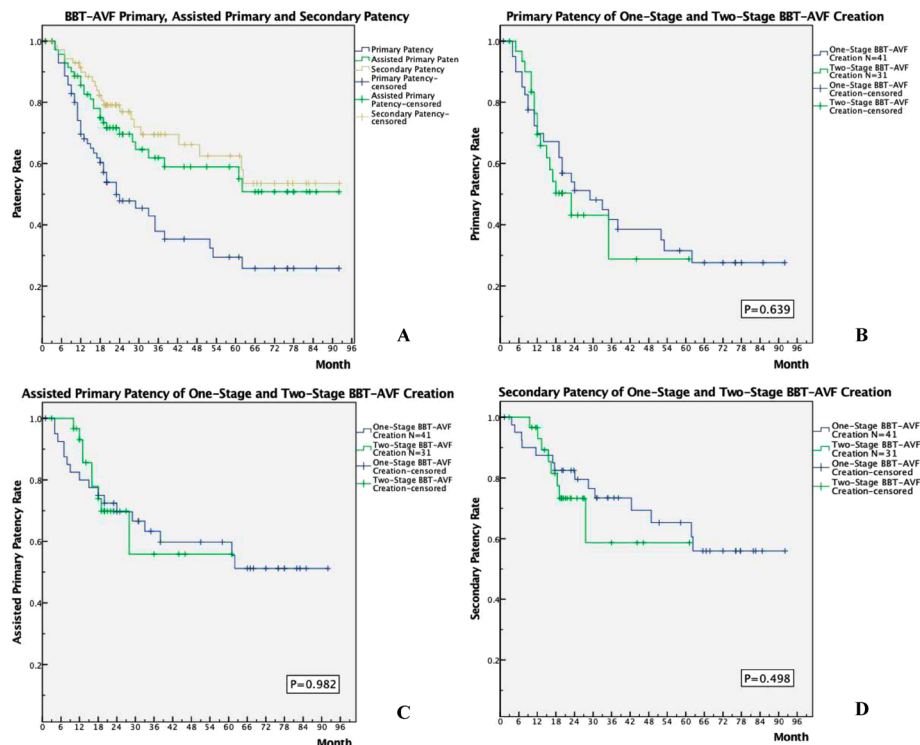


Fig. 2 BBT-AVF primary, assisted primary, and secondary patency rates, and comparison of patency rates between one-stage and two-stage groups.

A: BBT-AVF overall primary, assisted primary, and secondary patency rates. **B:** Comparison of primary patency rates between one-stage and two-stage BBT-AVFs. **C:** Comparison of assisted primary patency rates between one-stage and two-stage BBT-AVFs. **D:** Comparison of secondary patency rates between one-stage and two-stage BBT-AVFs.

BBT-AVF: brachiobasilic transposition arteriovenous fistula

of 6–24 months was published by El Mallah⁷⁾ in 1998. In his study, 40 patients were randomized equally into 2 groups after matching for age and sex. The patency rates in the early postoperative period (4 weeks after operation) were higher in the two-stage group (60% in the one-stage vs. 90% in the two-stage group, $p < 0.05$), whereas the overall patency rates at the end of follow-up also favored two-stage procedures (50% in the one-stage vs. 80% in two-stage group, $p < 0.05$). This study was one of the earliest studies to compare surgical techniques in BBT-AVF, with greatly different endpoints as compared to our current study. Thus, interpretation and comparison are of limited value. The second RCT was published by Kakkos et al.⁸⁾ in 2015 to compare one-stage and two-stage BBT-AVF creation prospectively. However, their study was pre-terminated for significantly lower maturation rate in one-stage procedures (3/9, 33%) compared to two-staged procedures (7/7, 100%) ($p = 0.011$). Their total sample size was 16, including 9 one-stage and 7 two-stage procedures, with comparable demographics. After excluding the initial failures, log-rank analysis revealed a trend for better 12-month primary patency rates of one-stage over two-stage procedures (100% vs. 57%, $p = 0.08$), whereas 12-month assisted primary and secondary patency rates of one-stage and two-stage procedures were equivalent. Again, the above conclusions were of limited value due to the small sample size and high primary failure rate.

The lack of significant difference in failure, patency, and postoperative complication rates between the one-stage and two-stage procedures in our study is similar to that of two separate systematic reviews by Bashir et al.⁹⁾ and Cooper et al.¹⁰⁾ Eight eligible studies from 1998 to 2013 were meta-analyzed, including 1 randomized-control trial and 7 retrospective cohort studies.^{5,7,11–16)} From 859 BBT-AVFs created in 849 patients, 366 were one-stage procedures and 493 were two-stage procedures, and there was no difference in failure and patency rates within the two groups. Postoperative complications were also compared between the two groups in pooled data analysis. Again, no statistically significant difference was demonstrated. As such, although one-stage procedure is often viewed to be technically more difficult in view of smaller vessel caliber, it does not seem to affect the overall failure and patency rates.

Nonetheless, our study brings forth the behavioral characteristics of both one-stage and two-stage BBT-AVF creation in an Asian population and reaffirms the finding that there is no statistically significant difference in patency rates between the two groups in an Asian setting, which is in line with various international studies.

A major argument against two-stage procedure is the higher cost due to 2 separate procedures required. As demonstrated in our study, the mean medical cost of the two-

stage procedure was nearly twice that of the one-stage procedure, at SGD 2,402 and SGD 1,245, respectively. We did not include the additional medical costs required for further procedures to maintain assisted primary or secondary patency as there was no statistical difference in the assisted primary and secondary patency rates between the two groups. A recent single-center study within the American population analyzed the cost-effectiveness of one-stage and two-stage procedures on the quality of life of patients.¹⁷⁾ The study analyzed 57 one-stage and 74 two-stage BBT-AVFs created from 2007 to 2015. The authors concluded that although both methods had similar maturation rates, two-stage BBT-AVF had statistically significant higher primary and secondary patency rates at 12 and 24 months, respectively. More interestingly, they also performed the cost-effective analysis. Despite a higher overall cost, two-stage BBT-AVF was found to be more cost-effective than one-stage BBT-AVF (quality-adjusted life year for two-stage vs. one-stage BBT-AVF, 3.74 vs. 3.32) in a 5-year model when secondary patency outcomes were considered.

Although no statistically significant difference in patency rates was derived from this study, the choice of one-stage vs. two-stage BBT-AVF creations does impact the patient in other medico-psycho-social aspects (which were not specifically covered in this study). One-stage BBT-AVF creation has benefits of a single operation, shorter operation-to-cannulation time, and lower overall cost. Meanwhile, the disadvantage of this procedure is increased technical difficulty because of the small vein caliber. For the 24% of patients within the one-stage group with primary failure, we had subjected them to a larger operation with increased morbidity in vain. Two-stage procedure has benefits of larger vein caliber, easier mobilization during second stage, and interval selection of patients suitable for superficialization. For the 21% of patients within the two-stage group with primary failure, we have saved patients from more extensive superficialization operation. Meanwhile, as expected, the two-stage group incurred a higher medical cost and had a higher fall-out risk while waiting for the second-stage procedure. In the two-stage procedure, patients are subjected to repeated perioperative risks and generally require additional hospital visits, as compared with the one-stage group.

In summary, considering statistically equivalent failure and patency rates, the clinical decision to perform one-stage or two-stage BBT-AVF creation should be primarily patient-focused, personalized, and decided after comprehensively weighing and discussing the associated risks and benefits.

We noticed higher 12-month assisted primary and secondary patency rates in two-stage BBT-AVF creation than one-stage BBT-AVF creation in our study. However, these

differences were not statistically significant. This phenomenon may be explained by the fact that the two-stage procedure generally has a bigger arterialized vein size to begin with once the second stage surgery is completed, and hence will logically result in higher short-term patency rates. However, such benefit becomes less significant in the long term. In fact, longer term (24 months and beyond) primary, assisted primary, and secondary patency rates seemed to be higher in the one-stage group, as shown in the cross-over in survival curves in Fig. 2 (though not statistically significant). These observations and explanations await further evidence from multicenter RCTs with a larger sample size.

There are several limitations in our study. First, our study was a single-center retrospective review with a lower level of evidence compared with other prospective RCTs. Besides, our sample size was relatively small due to the single-center design and caseload. Thus, the outcomes are more susceptible to bias, such as treatment selection bias by surgeon preference and patient expectation. Studies with a larger sample size are warranted to minimize the confounding factors and reach more convincing conclusion. Last but not the least, we did not include operation-to-cannulation time in our analysis, which is an important factor in decision making.

Conclusion

There was no significant difference between the primary failure rates and primary, assisted primary, secondary patency rates, as well as postoperative complications between one-stage and two-stage BBT-AVF creation in our study comprising the Asian population. Fifteen percent patients in the two-stage group did not complete their second stage superficialization. Both one-stage and two-stage BBT-AVF creation procedures confer good outcomes with overall 12-month primary patency, secondary patency, and primary failure rates at 70%, 90%, and 23%, respectively.

Disclosure Statement

The authors declare that there is no conflict of interests with regard to the publication of this article.

Author Contributions

Study conception: ZJL

Data collection: BH, HY

Analysis: BH, HY

Investigation: BH, HY

Writing: HY

Critical review and revision: all authors

Final approval of the article: all authors

Accountability for all aspects of the work: all authors

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