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Original Article

Forearm and Upper Arm Basilic Vein Transposition Arteriovenous Fistula for Patients Undergoing Hemodialysis

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Abstract

Objective: The aim of the present study was to evaluate the functional patency of the standard vascular access surgery and basilic vein transposition (BVT) arteriovenous fistula (AVF) in a single institution.

Methods: We reviewed cases of vascular access surgery performed between September 1, 2011 and August 31, 2019. Demographic and postoperative surveillance data were collected. BVT patients were either found unsuitable for or had failed any of the direct AVF options prior to transposition surgery.

Results: A total of 561 patients (325 men and 236 women) underwent vascular access surgery in the 9-year period. The mean age was 58.8 ± 14 years. The causes of chronic renal failure were diabetes (43%) and hypertension (86%). The mean follow-up duration was 28.6 ± 22.9 months. A total of 75 patients (41 men and 34 women) underwent BVT. The mean fistula maturation time was 1.9 ± 1.7 months in upper arm BVT and 2.6 ± 1.2 months in the forearm BVT. The maturation rate was 90% in the upper arm BVT and 86% in the forearm BVT. No bleeding, thrombosis, failure, pseudoaneurysm, or rupture occurred. The mean follow-up time in the BVT group was 31.6 ± 19.7 months. BVT functional patency assessed at 12, 24, and 36 months was 91%, 83%, and 72%, respectively, in the upper arm, and 76%, 51%, and 45%, respectively, in the forearm.

Conclusion: BVT is an alternative vascular access surgery with excellent initial maturation and patency rates, and should be considered in patients undergoing hemodialysis with primary failure of the fistula or naive veins not suitable for surgery. It is less expensive compared with the use of polytetrafluoroethylene grafts for secondary access.

Keywords: Vascular access surgery, Basilic vein transposition, Hemodialysis

Introduction

Vascular access is necessary in patients with chronic renal failure requiring dialysis. Brescia et al.[1] first introduced autologous vascular access surgery for hemodialysis in 1966. The ideal hemodialysis access is via a radial to cephalic arteriovenous fistula (AVFs) or a brachial to cephalic AVF. However, in some patients, the veins are not suitable for primary AVF, or the primary fistula fails, leaving the use of a synthetic graft, i.e., arteriovenous grafts (AVG) as the only option for venous access. However, AVG is associated with higher rates of complications and lower patency than AVF, and is more expensive.

Major healthcare coverage schemes in Thailand also limits the use of synthetic grafts. The 2019 Kidney Disease Outcomes Quality Initiative (K/DOQI) Clinical Practice Guidelines in Vascular Access recommend placement of autologous arteriovenous access in the following order of decreasing preference: radiocephalic AVF at the nondominant wrist, brachiocephalic AVF at the elbow, transposed brachial-basilic vein fistula, and arteriovenous graft in the upper arm in suitable patients.[2]

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The basilic vein transposed (BVT) to a brachial artery AVF was introduced in 1976 by Dagher et al.[3] and reported again in 1996. Only a limited number of studies have reviewed the patency of this operation and its technique. The advantages of this method include improvement in patency and a significant reduction in infection rate.[4-7] Its disadvantages include technical difficulty, longer period of maturation before use for hemodialysis, longer skin incision size, and infection.

The aim of the present study was to review the BVT technique, which is essentially an autologous arteriovenous graft, as performed in a single institution. The results of the BVT AVF were assessed and compared to those of standard vascular access surgery.

Methods

In the present retrospective cohort study, we reviewed the medical records of 561 cases of vascular access surgery performed at our hospital from September 1, 2011, to August 31, 2019. Data including demographics and timing of first cannulation or the timing of any complications were collected.

The fistula was placed preferentially in the non-dominant arm and in the most distal position that appeared feasible by preoperative physical examination and Doppler ultrasound (USG) assessment. Patients with a palpable radial pulse and a visible cephalic vein 2 mm from the wrist to the antecubital fossa with a tourniquet in the non-dominant forearm had radiocephalic AVF. Patients without these features, but with a palpable brachial pulse and a cephalic vein 2 mm in the upper arm, had brachiocephalic AVF.

Patients without suitable autologous anatomy had upper arm brachioaxillary straight graft (AVG) access or forearm arteriovenous loop graft (AVLG), depending on the diameter of the antecubital vein. If the diameter of the antecubital vein was > 5 mm, the patients underwent AVLG.

In the BVT group, the patients were either unsuitable for or had failed any of the direct AVF options. We selected patients with a basilic vein in the mid-upper arm area, greater than 5 mm by preoperative USG, the size of the vein around the elbow expanding greater than 3 mm, and the size of the basilic vein at the mid forearm greater than 4 mm after tourniquet was applied.

Radiocephalic AVF and brachiocephalic AVF were created by anastomosing the end of the cephalic vein to the side of the artery with continuous 7-0 polypropylene sutures. Operations were performed under local anesthesia.

Both AVG and AVLG procedures were performed on an in-patient basis with an average hospital stay of 4 to 5 days. The anastomosis was created with 7-0 polypropylene sutures on the arterial side and with a CV-6 polytetrafluoroethylene monofilament suture on the venous side. The vascular prostheses used in this study were 6 mm or 4-7 mm tapered standard wall vascular grafts. The operations were performed under general anesthesia.

For the upper arm BVT, we performed a two-stage procedure. Brachio-basilic AVF was first performed under local anesthesia. After surveillance in the clinic, the second-stage was scheduled under general anesthesia. The incision in the second stage was extended in a sigmoid shape along the cubital fossa through the basilic vein located in the medial condyle of the humerus and along the bicipital groove, up to the axillary area. The vein was superficialized over the fascia by ligating the lateral branches during the mobilization of the basilic vein, while the cutaneous medialis nerve of the forearm was preserved, lifting the transposed vein superficially and anteriorly under the skin flap (Figure 1).

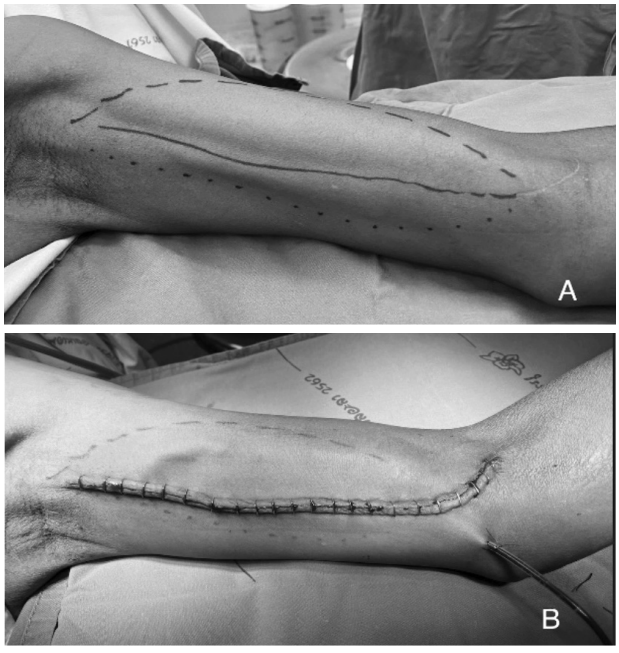

Figure 1 (A) Second stage procedure after 2 months of prior brachio-basilic arteriovenous fistula, with ultrasonography mapping for upper arm basilic vein. (B) After the basilic vein was delivered through the subcutaneous flap

Table 1 Estimate costs of various vascular access surgery in Thai baht

Procedure	Operative cost	Anesthetic cost	Vascular graft cost	Estimate total cost
AVF	7500	-	-	7500
AVG or AVLG	17500	4000	18000	39500
BVT 1st stage	7500	-	-	19000
BVT 2nd stage	7500	4000	-	

AVF: arteriovenous fistula; AVG: arteriovenous grafts; BVT: Basilic vein transposition

For the forearm BVT, distal forearm ulnar-basilic AVF was performed under local anesthesia. After surveillance in the clinic, a second-stage procedure was scheduled. A longitudinal incision was made along the forearm basilic vein. The forearm basilic vein was carried over the fascia by tying all the lateral branches, and transposed superficially and anteriorly by the flap created in the volar aspect of the forearm.

Total estimated costs of each procedure are shown in Table 1. The maturation time and rate, as well as functional patency of all types of arteriovenous fistulas and arteriovenous grafts were analyzed. Each patient was followed in the Outpatients Department.

Maturation time was defined as the interval from the time of access placement to the first successful cannulation. Functional patency (intervention-free patency probability) was calculated based on the time interval from access placement to any intervention designed to maintain or reestablish patency, access thrombosis, or the time of patency measurement.

Statistical analysis was performed using Windows SPSS (version 14.0; SPSS Inc., Chicago, IL, USA). The ANOVA F-test was used to compare Normally distributed data and the chi-square test was used for categorical data. Comparison of patency probability curves was done using the log-rank test. Statistical significance was set at $p < 0.05$.

Results

From a database of 561 consecutive vascular access patients, 289 upper extremity AVF procedures were identified as radiocephalic fistula (RC AVF, 227 patients) and brachiocephalic fistula (BC AVF, 62 patients) groups. A total of 197 patients with upper extremity arteriovenous prosthesis graft procedures were identified as forearm AVLG (135 patients) and upper arm straight graft (AVG) groups (62 patients); 75 patients in the upper extremity BVT procedures were identified as forearm BVT (36 patients) and upper arm BVT (39 patients) groups.

In our study, fistula formation by RC AVF, BC AVF, AVLG, AVG, upper arm BVT, and forearm BVT were examined with regard to functional patency. No significant difference was found between the groups in terms of sex or underlying disease (Table 2). However, a significant difference was found in the age of the patients between the groups. The average age in the AVG and AVLG groups were 66.7 ± 10.5 years and 64.4 ± 11.2 years, respectively, which were significantly different from other groups ($p < 0.001$).

Table 2 Characteristics of patients by type of vascular access surgery

Characteristics	RC AVF (N = 227)	BC AVF (N = 62)	Forearm AVLG (N = 135)	Upper arm AVG (N = 62)	Forearm BVT (N = 36)	Upper arm BVT (N = 39)	*p*-value
Age (years, means ± SD)	56 ± 14.1	53.5 ± 16.4	64.4 ± 11.2	66.7 ± 10.5	52.2 ± 17.1	54.9 ± 12.4	< 0.001
Gender, Men	63%	66%	55%	44%	58%	51%	0.109
Hypertension	89%	87%	82%	76%	89%	49%	0.320
Diabetes	42%	42%	51%	40%	28%	41%	0.291
CAD	10%	5%	11%	7%	0	8%	0.900
CVD	4%	3%	4%	5%	3%	0	0.917

AVF: arteriovenous fistula; AVG: arteriovenous grafts; AVLG: arteriovenous loop graft; BC: brachiocephalic; RC: radiocephalic; BVT: basilic vein transposition; CAD: coronary artery disease; CVD: cerebrovascular disease

Functional patency of RC AVF, BC AVF, AVLG, and upper arm AVG are shown in Figures 2 and 3. Functional patency in our study at 12, 24, and 36 months were 84%, 76%, and 74%, respectively, in the RC AVF group; 93%, 84%, and 81%, respectively in the BC AVF group; 77%, 58%, and 36%, respectively, in the AVLG group; 97%, 73%, and 58%, respectively, in the upper arm AVG group.

The functional patency of the upper arm and forearm BVT are shown in Figure 4. Functional patency in our study at 12, 24, and 36 months were 91%, 83%, and 72%, respectively for the upper arm BVT; and 76%, 51%, and 45%, respectively for the forearm BVT.

We defined the overall AVF group as a combination of RC AVF and BC AVF, and AVG and AVLG into the overall AVG group. We compared the functional patency between these groups and both BVT groups. The patency of all AVF, all AVG, forearm BVT, and upper arm BVT are shown in Figure 5. Functional patency of all AVF's in our study at 12, 24, and 36 months were 86%, 78%, and 75%, respectively. When compared with the AVF group, the AVG group demonstrated inferior cumulative functional patency with rates of 83%, 63%, and 43% at 12, 24, and 36 months, respectively.

There was no postsurgical bleeding, thrombosis, pseudoaneurysm, or rupture in any of our patients.

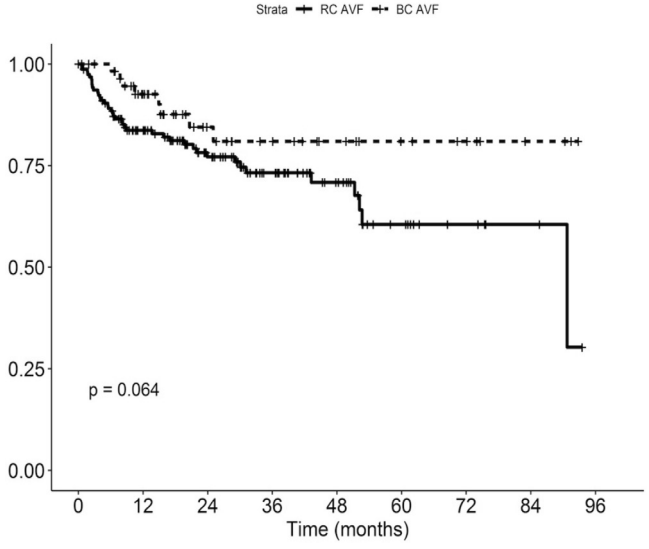

Figure 2 Patency probability of two types of arteriovenous fistula

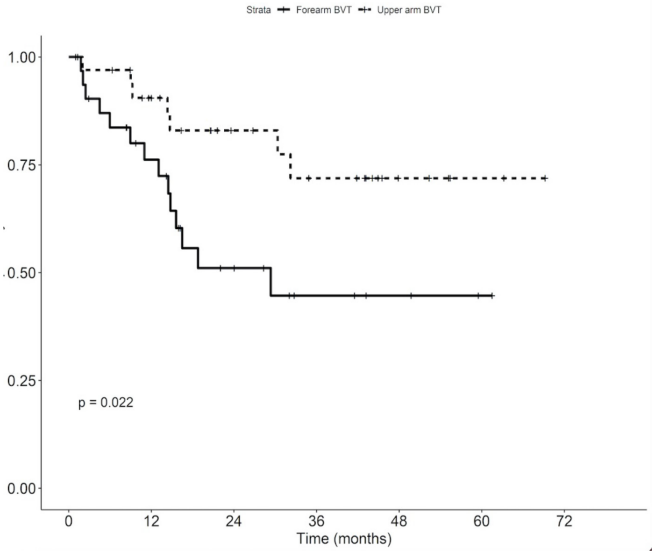

Figure 4 Patency probability of forearm and upper arm basilic vein transposition access procedures

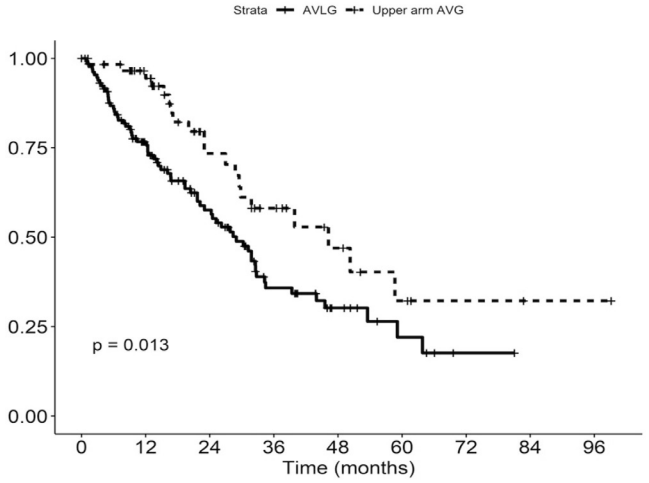

Figure 3 Patency probability of two types of arteriovenous grafts

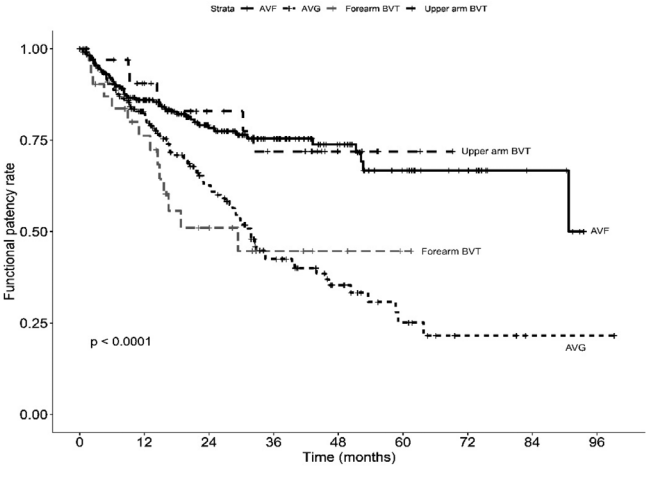

Figure 5 Comparison of patency probabilities among the various surgical vascular access procedures

The one case of surgical wound disruption was due to skin flap necrosis in the upper arm of the BVT, but this was successfully treated with surgical debridement and healing by secondary intention.

The mean fistula maturation time was 1.9 ± 1.7 months in the upper arm BVT and 2.6 ± 1.2 months in the forearm BVT groups. The maturation rate was 90% in the upper arm BVT and 86% in the forearm BVT. The mean follow-up time in the BVT group was 31.6 ± 19.7 months.

Discussion

The establishment and maintenance of vascular access for patients with ESRD is costly, with significant morbidity. AVF surgery to ensure adequate blood flow during hemodialysis, has been performed for many years. The optimal flow rate was ≥ 200 mL/min with an easy-to-cannulate dialysis needle. For this purpose, the arteries and veins of the upper limbs are commonly used. In the majority of our patients, autologous veins are not suitable for the construction of radiocephalic or brachiocephalic AVF. Therefore, alternative methods to create a fistula must be used. In compliance with the KDOQI recommendations recently, BVT is the preferred method in our practice. Thus, we can avoid the use of synthetic vascular grafts as these incur costs that are not covered by most medical expense coverage schemes.

A review of the literature showed that AVFs had primary patency varying between 36% to 90%, 28% to 88%, and 39 % to 80% at 12, 24, and 26 months, respectively.[7,8] In our study, the functional patency of AVFs was close to the primary patency rate of those reviews. Previous reports showed that AVGs had primary patency varying between 22% to 74%, and 13% to 83% at 12 and 24 months, respectively.

BVT was first described in 1976 by Dagher et al.[3] and has been increasingly accepted as a viable option for secondary or tertiary vascular access.[9] Few studies in the literature have compared different techniques for BVT.[10] Kakkos et al. compared one-stage and modified two-stage BVT and found a fistula maturation rate of 86% in the one-stage group and 82% in the two-stage group. They concluded that there was no significant difference between groups.

In our study, we performed only a two-stage procedure; the rate of fistula maturation was 90% in the upper arm BVT and 86% in the forearm BVT. A review of the literature revealed that the rate of fistula maturation following BVT was 62% to 97%.[11,12,13] The patency at 36 months reported by Cantelmo et al.[14] was 57%, whereas it was 52% at 30 months, as reported by Rivers et al.[15] In the literature, the rate of thrombosis was reported to vary widely between 3% to 38%. Hill et al.[16] found that BVT using basilic veins of at least 4 mm in diameter had a higher success rate than BVT using smaller veins. A randomized study by El Mallah[17] found a 2-year cumulative patency rate of 50% for one-stage BVT and 80% for two-stage procedures.

A wide range of reported patency in recent publications was based on the different emphasis placed by Fistula First and K/DOQI guidelines on the various types of AVF. This may lead to more BVT failures as patients with more difficult access are selected for BVT procedures.[18] Although BVT procedures were performed in the majority of cases based on a medical expense coverage basis, many of our cases did not receive any assisted maturation procedures after AVF failure.

The main limitation of our study was its non-randomized design. We performed BVT based on the financial coverage, in patients who had exhausted other autologous options and could not be supported for the use of a prosthetic graft.

Conclusion

Simple AVFs (radiocephalic fistula, brachiocephalic fistula) should be the first vascular access because of their simplicity, good potency, low complication rate, and low cost. In our experience, when a simple AVF failure occurs, BVT is technically feasible with good patency, and less expensive than AVGs. BVTs should be used in preference to polytetrafluoroethylene grafts for secondary access.

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บทคัดย่อ **การการผ่าตัดหลอดเลือดเพื่อการฟอกเลือดในผู้ป่วยไตวายระยะสุดท้าย โดยการผ่าตัดย้ายตำแหน่งหลอดเลือดดำเบสิลิก เมื่อเปรียบเทียบกับการผ่าตัดวิธีพื้นฐานวิธีอื่น**

เอกพจน์ เชี่ยวชลาคม, พ.บ.

กลุ่มงานศัลยศาสตร์ โรงพยาบาลยะลา

วัตถุประสงค์: เพื่อศึกษาถึง Patency rate ของการผ่าตัด basilic vein transposion (BVT) เมื่อเปรียบเทียบกับการผ่าตัด arteriovenous fistula (AVF) อื่นๆ หรือการใช้หลอดเลือดเทียม arteriovenous graft (AVG)

วิธีการศึกษา: การศึกษาครั้งนี้จะศึกษาตามรุ่นย้อนหลัง ในกลุ่มผู้ป่วยที่เข้ารับการผ่าตัดหลอดเลือดฟอกไต ที่โรงพยาบาล ยะลาทั้งหมด ในช่วงเดือนมิถุนายน พ.ศ. 2553 จนถึง เดือนมิถุนายน พ.ศ. 2562 โดยเก็บข้อมูลเกี่ยวกับลักษณะผู้ป่วย และศึกษาวิเคราะห์ functional patency rate ของการผ่าตัดหลอดเลือดฟอกไตแต่ละวิธี โดยการใช้การวิเคราะห์ข้อมูลแบบพรรณนา ได้แก่ อัตราส่วนร้อยละ (Percentage) ค่าเฉลี่ย (Mean) และความถี่ (Frequency) การวิเคราะห์ข้อมูลแบบอ้างอิง ได้แก่ Logrank test การวิเคราะห์ข้อมูลค่าสถิติดังกล่าว

ผลการศึกษา: จากผู้ป่วยทั้งหมด 561 ราย ที่ได้รับการผ่าตัดทำหลอดเลือดสำหรับฟอกไตในช่วงระยะเวลาที่ทำการศึกษา พบว่าอายุเฉลี่ยของผู้ป่วยเท่ากับ 58.8 ± 14 ปี สาเหตุที่ทำให้เกิดภาวะไตวายเรื้อรังที่พบมากที่สุด คือ ความดันโลหิตสูง (85.9%) และ เบาหวาน (43.1%) ค่าเฉลี่ยของการตรวจติดตามภายหลังการผ่าตัดคือ 28.6 ± 22.9 เดือน มีผู้ป่วยจำนวน 75 คน (ผู้ชาย 41 ราย และ ผู้หญิง 34 ราย) ที่ได้รับการผ่าตัดย้ายตำแหน่งหลอดเลือดดำเบสิลิก ค่าเฉลี่ยระยะเวลาในการเริ่มใช้งานหลอดเลือดได้ครั้งแรก (maturation time) ของกลุ่มผู้ป่วยที่ได้รับการผ่าตัดย้ายตำแหน่งหลอดเลือดดำเบสิลิกที่ต้นแขน (upper arm basilic transposition) และการผ่าตัดย้ายตำแหน่งหลอดเลือดดำเบสิลิกที่แขน (forearm basilic transposition) อยู่ที่ 1.9 ± 1.7 เดือน และ 2.6 ± 1.2 เดือน ตามลำดับ มีอัตราความสำเร็จของการผ่าตัด (maturation rate) อยู่ที่ 90% และ 86% ตามลำดับ มี Functional patency ที่ 12 เดือน, 24 เดือน, 36 เดือน อยู่ที่ 91%, 83%, 72%. และ 76%, 51% และ 45% ตามลำดับ ไม่พบภาวะแทรกซ้อน เช่น ภาวะเลือดออก หลอดเลือดอุดตัน และ pseudoaneurysm ค่าเฉลี่ยของการตรวจคิดตาม (mean follow up time) ของผู้ป่วย อยู่ที่ 31.6 ± 19.7 เดือน

สรุปผลการศึกษา: การผ่าตัดย้ายตำแหน่งหลอดเลือดดำเบสิลิก (Basilic vein transposition) เป็นการผ่าตัดทางเลือกที่ถือว่ามีผลการผ่าตัดที่ดี สามารถใช้งานได้เร็ว อัตราความสำเร็จในการผ่าตัดที่สูง และมีอายุการใช้งานที่ยาวนาน หากพิจารณาจาก patency rate เป็นทางเลือกการผ่าตัดที่ควรใช้พิจารณา ในกรณีที่ผู้ป่วยไม่ประสบความสำเร็จจากการผ่าตัดทำหลอดเลือดฟอกไตพื้นฐานอื่นๆ หรือในผู้ป่วยที่หลอดเลือดดำในตำแหน่งปกติไม่มีความเหมาะสมที่จะนำมาใช้ผ่าตัดทำหลอดเลือดฟอกไตสามารถลดความจำเป็นในการใช้หลอดเลือดเทียม ทำให้ช่วยลดค่าใช้จ่ายในการผ่าตัดลงได้