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Midterm outcomes of endoscopic-assisted brachial-basilic arteriovenous fistula creation

Ghaith Almhanni, MD,[a] Indrani Sen, MBBS,[a] Sai Vang, PAC,[a] Shaun Marczak, PAC,[a] Kirk Herzog, PAC,[a] Mark Twesme, PAC,[a] Matthew Ryba, PAC,[a] Gloria Krueger, PAC,[a] Rachel Jack, CNP,[a] Jason Beckermann, MD,[b] Thomas Carmody, MD,[a] *and* Tiziano Tallarita, MD,[a] *Eau Claire, WI*

ABSTRACT

Endoscopic vein harvest remains underused in single-stage brachial-basilic arteriovenous fistula creation. We analyzed our results with the use of this technique in a cohort of predominantly obese (body mass index ≥30 kg/m^2) patients. Demographics, intraoperative details, and outcomes for all consecutive patients who underwent single-stage endoscopic-assisted brachial-basilic arteriovenous fistula creation between 2020 and 2022 at a single institute were analyzed retrospectively. The primary outcomes were technical success, fistula maturation, and primary assisted and secondary patency rates. Of the 11 patients (7 men; mean age, 62 ± 11.6 years), 7 (64%) already required dialysis at referral. The mean body mass index was 34 ± 7 kg/m^2, 64% were obese, and an additional 27% were overweight. The medical comorbidities included hypertension in 11 patients (100%), diabetes in 7 (64%), and smoking in 8 (73%). Technical success was 100%, with no intraoperative complications. The median procedural length was 231 minutes (range, 183-302 minutes). Early complications in two patients (18%) included bleeding of the venous side branch requiring ligation and the loss of thrill requiring division of a tethering bridge of a large tributary. The maturation rate was 100%, and the brachial-basilic arteriovenous fistula was successfully accessed in all patients who required dialysis. At 12 months, the primary assisted and secondary patency rates were 90% ± 10% and 100%, respectively. Reintervention in seven patients (64%) included successful angioplasty in four, thrombectomy in two, and aneurysm resection with an interposition graft in one patient. Endoscopic vein harvest can be used for single-stage brachial-basilic arteriovenous fistula creation with good technical success and favorable maturation and patency rates, even for obese patients. (J Vasc Surg Cases Innov Tech 2024;10:101382.)

Keywords: Arteriovenous fistula; Brachial-basilic; Dialysis; Endoscopic; Obesity

The number of patients with newly registered end-stage renal disease increased from 94,466 in 2000 to 134,862 in 2019.[1] An autogenous brachial-basilic upper arm transposition arteriovenous fistula (BB-AVF) is created when the radial artery and/or the cephalic vein are unsuitable vessels for hemodialysis access.[2] However, long incisions and extensive tissue dissection are required with this operation, increasing the risk of pain, infection, lymph leakage, and hematoma.[3]

Endoscopic-assisted BB-AVF was introduced in 2001 to reduce tissue disruption and the length and number of incisions.[4,5] However, this technique is not widely used, and the outcomes are not well reported, especially those for obese patients.

The aim of this study was to analyze our initial experience with endoscopic BB-AVF creation in a predominantly obese patient population and provide a detailed, step-by-step description of the technique to facilitate its wider adoption.

METHODS

The demographic, operative, and postoperative data of patients who underwent single-stage endoscopic-assisted BB-AVF creation at a single institute from March 2020 to June 2022 were reviewed retrospectively. The inclusion criteria included end-stage renal disease, a requirement for AVF creation, a ≥3-mm basilic vein diameter from the upper forearm to the axilla, an unsuitable radial artery and/or cephalic vein distally and proximally for hemodialysis access, an anticipated long duration of hemodialysis, and sufficient time for fistula maturation. All the patients underwent preoperative imaging with vein mapping to evaluate the patency and caliber of the cephalic and basilic veins and the absence of atherosclerotic disease of the radial, brachial, and axillary arteries. The basilic vein was assessed using ultrasound (US) from the upper forearm to the axilla to

From the Department of Cardiovascular Surgery,[a] and Department of General Surgery,[b] Mayo Clinic Health System.

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Correspondence: Tiziano Tallarita, MD, Department of Cardiovascular Surgery, Mayo Clinic Health System, 1400 Bellinger St, Eau Claire, WI 54720 (e-mail: tallarita.tiziano@mayo.edu).

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Fig 1. Ultrasound (US)-guided identification of the basilic vein and its tributaries, which are marked on the skin.

ensure the diameter was adequate (≥3 mm) and that the vein had an adequate length and had no early connection with the brachial veins.

In patients with a history of central vein stenosis, the presence of superficial venous collateral vessels in the upper chest, or recent upper extremity swelling, an upper extremity venogram was performed to assess central vein patency. The Allen test was performed for all patients to assess palmar arch integrity. Obesity was defined as a body mass index (BMI) of ≥30 kg/m^2. Successful fistula maturation was considered when the basilic vein reached the diameter ≥6 mm and a flow volume of ≥600 mL/min, regardless of whether the AVF was accessed during the study period. The institutional review board approved the present study, with an exemption for the requirement for written patient consent (approval no. 23-004782).

Surgical technique. The patient is placed supine on the operating table. The arm is abducted 90° and placed on an arm table. The arm and axilla are prepared and draped circumferentially in standard sterile fashion. The brachial artery and basilic vein with its tributaries are marked on the skin using US guidance (Fig 1).

A transverse incision of ∼2 cm is made between the brachial artery and basilic vein. The basilic vein is identified first, dissected from the surrounding tissue, and controlled with a vessel loop. With the help of a small Army-Navy retractor, the basilic vein is freed 3 cm proximally and distally. At this point, a seal trocar (Fig 2, *A*) is inserted through the same incision, and carbon dioxide (CO_2) is inflated to create a working tunnel (Fig 2, *B*). The endoscope we use is the Vasoview Hemopro (Maquet; Fig 3). It is important to create only one plane of dissection around the basilic vein. If more than one plane is created in multiple directions, the correct tunnel might not be fully expanded, because the gas will simultaneously pressurize all the tunnels created. This competing pressurization collapses the working tunnel, compromising the view. In an obese arm, it is not unusual to encounter what is termed a "pulsatile tunnel," where the CO_2 gas is not contained inside the tunnel but is easily dissipated and infiltrated into the surrounding tissue. This phenomenon will result in intermittent collapse of the tunnel. To improve visualization, the insufflation flow and target pressure can be increased ≤3 L/min and ≤15 mm Hg, respectively. Additionally, the arm can be temporarily wrapped with an elastic band to contain the gas during this part of the procedure.

The basilic vein is dissected circumferentially up to the axilla with an endoscope using a conical dissecting tip. During dissection, the medial cutaneous nerve and its branches are identified and carefully preserved to avoid inadvertent injury because of their close relationship to the basilic vein (Fig 4, *A*). The vein side branches are dissected with the endoscope for 2 to 3 cm from the basilic vein before being divided by bipolar cautery to minimize the risk of thermal injury to the basilic vein itself. Large tributaries (>3 mm in diameter) are ligated with 3-0 silk through a separate stab incision by grasping the tributary vein with a mosquito clamp under endoscopic visualization (Fig 4, *B*). Another option to control the venous side branches is the use of clips. However, the endoscope used in this study did not have an extra port to apply clips. If the patient has a generous arm size and/or the brachial artery is located >3 cm deep, an extra 5 to 10 cm of basilic vein is harvested in the upper forearm. The extra length allows for tunneling of the basilic vein superficially without tension at the anastomosis. Once the vein is fully mobilized, it is ligated and divided in the forearm. The basilic vein is exteriorized

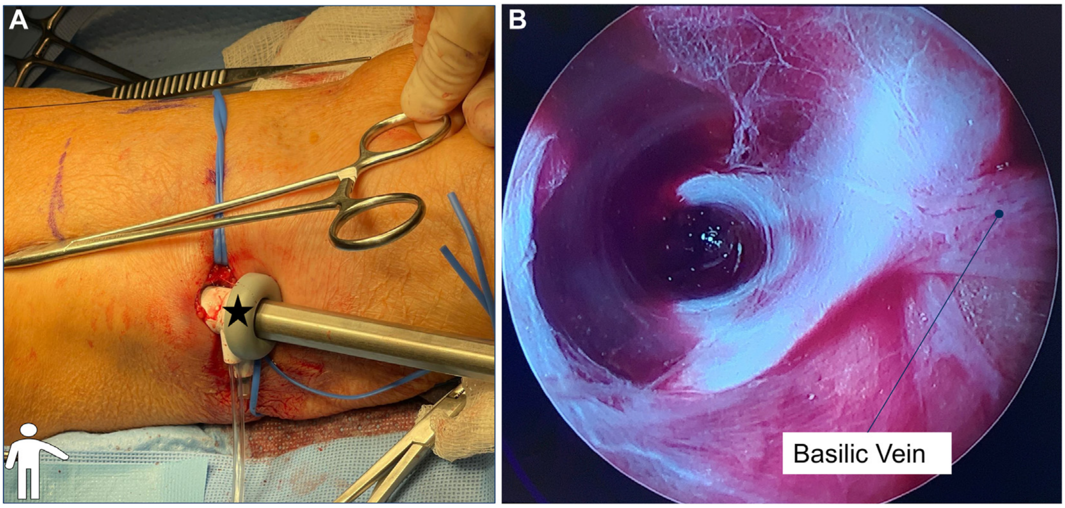

Fig 2. **A,** A transverse incision is made at the antecubital fossa, the basilic vein identified, and the trocar inserted over the incision (*asterisk*). **B,** A working tunnel is created by insufflating carbon dioxide (CO_2).

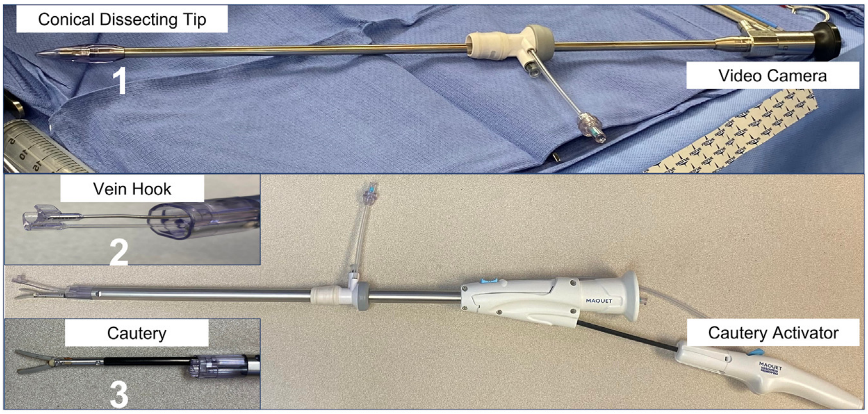

Fig 3. The different components of the endoscopic device. The endoscope has a conical tip (*1*) to create the tunnel, a U-shaped vein hook to be used during cauterization of the side branches (*2*), and a bipolar cautery to divide side branches while obtaining hemostasis (*3*).

through a small counter incision in the axilla (Fig 5, *A*). For an obese patient, we recommend making this incision ≥3 cm long to improve visualization of the distal basilic vein and avoiding twisting or missing large side branches that can cause bleeding, tethering, or compression of the basilic vein. It is important to keep endoscopic visualization of the vein during this part of the procedure to avoid twisting of the vein while it is exteriorized through the axillary incision. The side branches of the basilic vein are oversewn with 7-0 Prolene suture (Fig 5, *B*). The vein is dilated with heparin saline, and its superior aspect is marked with a blue marker to preserve the orientation and avoid twisting of the vein (Fig 5, *C*). Next, the brachial artery is dissected out for ∼5 cm in length and controlled with vessel loops. A subcutaneous tunnel is created from the brachial artery up to the axilla. The remainder of the procedure is the same as for standard AVF access creation, with an end-to-side anastomosis between the basilic vein and brachial artery. Once the anastomosis is completed, the brachial and radial pulse are palpated and insonated with Doppler ultrasound, and the fistula is assessed for a bruit. US is performed to interrogate the basilic vein for its diameter (homogeneous without abrupt interruption or a significant decrease in diameter, which might indicate twisting or external compression), arterial pulsation, and a gentle curve at the level of the elbow and axilla. The elbow and axilla represent the areas where the basilic vein takes a significant turn, and we give specific attention to the subcutaneous tissue in these areas needing limited release to ensure that no tethering or compression of the vein is present at these sites. We also check for a constant, strong thrill that

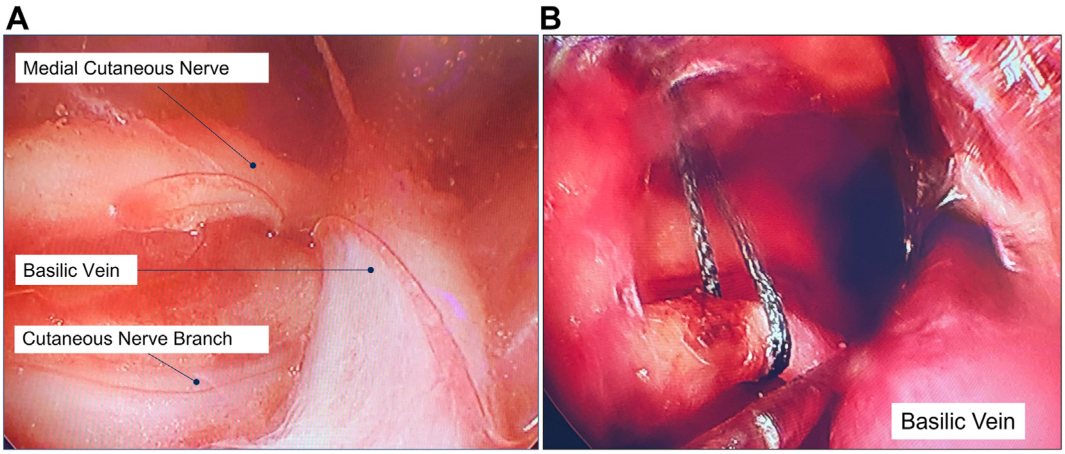

Fig 4. A, Intraoperative view showing the relationship of the medial cutaneous nerve and its branches with the basilic vein. **B,** A large (>3 mm) tributary is ligated with a 3-0 silk tie through a separate stab incision. The stab incision is made under direct endoscopic vision to avoid inadvertent injury to the basilic vein.

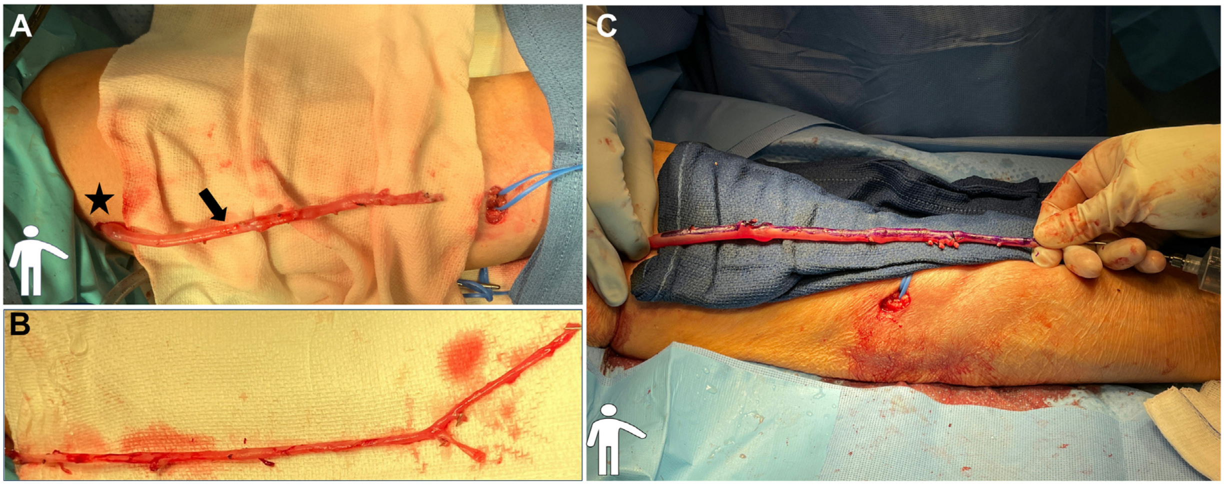

Fig 5. A, The dissected basilic vein (*arrow*) is exteriorized through a 3-cm counter incision in the axilla (*asterisk*). **B,** The side branches are oversewn and tested for hemostasis by distending the basilic vein with heparin saline. **C,** The superior aspect of the vein is marked with a blue marker for orientation during tunneling.

does not disappear by adducting or abducting the arm or bending the elbow. The wounds are closed in multiple layers. A gentle elastic bandage (ACE wrap; 3M) is applied, ensuring that the AVF is not compressed (rechecking for the presence of thrill and a radial pulse) by placing 4 $\times$ 4 gauze next to the AVF and at the level of the endoscopic tunnel where the basilic vein is originally located to facilitate obliteration of the tunnel of dissection.

Statistical analysis. Time-dependent end points (patency rates) were analyzed using the Kaplan-Meier test. Numerical variables are reported using the mean $\pm$ standard deviation and median and range. Categorical variables are reported as percentages. The Fisher exact test was used to compare the parameters between obese and nonobese patients. All statistical tests were performed using BlueSky Statistics software. A *P* value of $< .05$ was considered statistically significant.

RESULTS

Eleven patients (seven men [64%]; mean age, 62 $\pm$ 11.6 years) underwent single-stage endoscopic-assisted BB-AVF creation from March 2020 to June 2022. Of the 11 patients, 7 (64%) already required dialysis at the time of referral. The demographics, comorbidities, and cause of chronic kidney disease are included in

Supplementary Table I. Of the 11 patients, 7 (64%) were obese.

Technical success was 100% for both obese and nonobese patients, and none had required conversion to standard open surgery. The overall median procedural length was 231 minutes (range, 183-302 minutes). No difference was found in the procedural length between the obese and nonobese patients (median, 231 minutes [range, 183-302 minutes] vs median, 215 minutes [range, 187-249 minutes]; $P = .06$).

Early complications occurred in two patients (one obese patient and one nonobese patient). One patient was diagnosed in the recovery room with a rapidly enlarging hematoma, requiring reintervention to ligate a missed side branch at the axillary level. He was discharged the next day. On postoperative day 4, a second patient experienced a loss of AVF thrill. Seen in the emergency department, the AVF was still patent; however, the outflow was obstructed at the level of the axilla. He was brought to the operating room and underwent ligation and division of a large tributary that was compressing the basilic vein at the level of the axillary vein.

The wound check at follow-up showed that all wounds had healed without any signs or symptoms of infection in all obese and nonobese patients. The maturation rate in the obese and nonobese patients was 100%, with median maturation time of 55 days (range, 35-95 days; 60 days vs 46 days for obese and nonobese patients, respectively; $P = .27$). The AVF was successfully accessed in all the patients who required dialysis. At 6 months, the primary patency rate was 90%. At 12 months, the primary assisted and secondary patency rates were 90% ± 10% and 100%, respectively. At 18 months, the primary assisted and secondary patency rates were 77% ± 18.7% and 100%, respectively (Supplementary Table II). All AVFs were patent in the obese and nonobese patients at the last clinical follow-up, except for one AVF, which was occluded after 23 months in a nonobese patient. Seven patients (64%) required reintervention (three obese and four nonobese patients; $P = .19$), including successful angioplasty in four patients (36%), thrombectomy in two patients (18%), and aneurysm resection with an interposition graft, thrombectomy, and de-clotting in one patient (9%). At 5 and 10 months after AVF creation, two patients (18%) had died of respiratory failure and profound metabolic acidosis with ischemic hepatitis, respectively.

DISCUSSION

The purpose of this study was to analyze our early experience with endoscopic-assisted, single-stage, BB-AVF creation. Particular emphasis was given to describing the technique in a step-by-step fashion and providing tips for how to overcome any technical difficulties encountered when a new surgical technique is explored.

According to the Kidney Disease Outcomes Quality Initiative guidelines, autogenous AVF access is preferred to nonautogenous AVF access, and both are preferred to temporary dialysis catheters because of the lower infection rate and longer mid-term patency.[2,6-8] BB-AVF is considered an appropriate approach when forearm vessels are not suitable for AVF creation.[2] In this study, endoscopic vein harvesting showed equivalent outcomes across weight classes, albeit for a very small number of patients. Because of the small sample, it remains unknown whether this minimally invasive technique has a particular advantage for obese patients compared with an open surgical approach. In obese patients, the basilic vein can be deeper, requiring more tissue dissection and longer incisions, with an increased risk of wound healing complications and infection. However, in our study, the US assessment did not routinely report the distance of the basilic vein from the skin, which would have been a more precise indicator of challenging vein superficialization than obesity.

Importantly, obesity is the most significant risk factor for the development of diabetes,[9] which is associated with a higher incidence of nonhealing wounds and infection.[10-13] Endoscopic vein harvesting circumvents the requirement for extensive dissection and can potentially decrease the risk of wound healing complications and infection. This benefit can be even greater for obese and diabetic patients for the stated reasons. In our study, most of the BB-AVFs were created through a two small, 2- to 3-cm-long incisions and, although 64% of the patients were obese, none experienced wound healing complications or infection. Accordingly, Leone et al[5] reported their experience with endoscopic-assisted BB-AVF creation in 21 patients with a median BMI of 30 kg/m^2 and found no postoperative wound complications or infections, with only one case of transient numbness over the ulnar nerve distribution.

Obesity is also associated with decreased AVF maturation and patency rates in patients undergoing open AVF creation.[14] However, no data have shown whether obesity plays a major role in AVF maturation and patency rates in patients undergoing endoscopic BB-AVF creation. Leone et al[5] reported lower primary and secondary patency rates at 6 months (60% and 73%, respectively) in group of patients with a median BMI of 30 kg/m^2. However, details of obesity and the depth of the basilic vein from the skin were not provided. Martinez et al[15] found excellent primary patency of 88% at 12 months for patients undergoing endoscopic-assisted BB-AVFs creation; however, the BMI was not reported. Some of the possible reasons for the lower maturation and patency rates in obese patients include possible compression of venous outflow by excess axillary adipose tissue and persistent inflammatory status,[16,17] which could have predisposed patients to intimal hyperplasia and a greater need for reintervention.[18,19] In our experience, the maturation rate was excellent (100%), possibly because we routinely dissected off the axillary adipose tissue around the basilic vein to facilitate vein mobilization and tunneling.

The mid-term reintervention rate was, however, high (which is in line with the current literature); however, the assisted and secondary patency rates at 12 months were encouraging (90% and 100%) and were not influenced by obesity. In addition, some of the early reinterventions (eg, ligation of a missed venous side branch causing bleeding or external compression of the basilic vein) were a direct consequence of the learning curve, because they occurred in the early stages of the study when we were adapting a new technique.

Although in our study no conversion was required to a conventional open approach and no temporary sensational disturbances resulted from ulnar or medial cutaneous nerve injury and/or distention, these events are reported in similar studies.[4,5] One of the reasons for our excellent success rate was the presence in all cases of a navigated cardiac physician assistant-certified with experience in harvesting saphenous veins for cardiac bypass surgery, who could help in troubleshooting issues, when encountered by the vascular surgeon. In an obese arm, it is not unusual to encounter what is called a "pulsatile tunnel," in which the CO_2 gas is not contained inside the tunnel but dissipates and infiltrates into the surrounding tissue, resulting in intermittent collapse of the tunnel and poor visualization. To improve the visualization, the insufflation flow and target pressure were increased ≤3 L/min and ≤15 mm Hg. When managing large, obese arms, similar to open surgical BB-AVF creation, we recommend harvesting an extra 3 to 10 cm of the basilic vein in the forearm to avoid making the arterial anastomosis more proximal than the initial antecubital incision. By following this tip, we rarely had to perform the arterial anastomosis more proximally than the surgical incision.

Overall, the median procedural length was 231 minutes, longer than some would expect with a traditional surgical approach. The longer procedural time was likely due to a combination of our early experience (learning curve) and the predominant number of obese patients. All procedures were single stage and included the time for basilic vein dissection, superficialization, and anastomosis. Open surgical basilic vein superficialization in the obese arm can also be challenging and time consuming, especially if skin incisions are used.

This study did not include data regarding the cost effectiveness of the endoscopic approach vs traditional open surgery. Studying the literature for traditional surgery, Ghaffarian et al[20] concluded that the conventional two-stage transposition brachial-basilic AVF creation procedure is more cost effective than the single stage despite the costs of $4730 vs $4412, respectively. This conclusion was made after taking into consideration the lower quality-adjusted life years with the two-stage procedure and the secondary patency outcomes. Compared with open surgical AVF creation, the endoscopic approach might have higher initial costs but more advantageous overall costs in the mid-term, considering the lower incidence of wound complication and the excellent maturation rate and patency rates, especially in obese patients. Despite the potential benefits of this minimally invasive technique, only a few studies have been reported in the past 20 years, with similar maturation rates but different primary and secondary patency rates (Supplementary Table III).[4,5,21-24]

Our study has added value considering the current literature, because we describe in a very detailed fashion an underused approach for BB-AVF creation to facilitate adoption of this technique in the vascular surgery community and provided an optimization of the technique itself by routinely dissecting off the axillary adipose tissue around the basilic vein.

Study limitations. The limitations of our study were the retrospective design and small sample size, which are associated with selection bias and type β error. In addition, some of the results could have been influenced by our early experience.

CONCLUSIONS

We found that endoscopic vein harvest for single-stage BB-AVF creation is safe, avoids extensive tissue dissection, and does not affect the AVF maturation rate, mid-term primary assisted or secondary patency rates. Our early experience resulted in a high early reintervention rate but did not affect the maturation and patency rates. This technique should be considered for all patients who are good candidates for BB-AVF creation, with particular benefit for obese patients.

DISCLOSURES

None.

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Supplementary Table I. Comorbidities of patients who underwent endoscopic brachial-basilic arteriovenous fistula (AVF) creation

Pt. No.atient	Gender	BMI, kg/m^2	HTN	DM	HLP	Smoking history	CAD	PAD	Prior AVF	CKD cause	Frailty score
1	Male	32	+	+	+	+	+	–	+	HTN and DM	57
2	Female	44	+	+	+	+	–	+	–	DM	49
3	Female	39	+	+	+	+	+	+	–	HTN	34
4	Male	31	+	-	+	+	+	–	–	HTN	32
5	Male	29	+	+	+	–	–	+	–	DM	50
6	Male	28	+	+	–	–	–	–	–	HTN and DM	34
7	Male	35	+	+	+	–	+	+	–	HTN	40
8	Male	24	+	–	+	+	–	–	–	Unknown	32
9	Male	26	+	–	+	+	–	–	–	HTN	35
10	Female	45	+	+	+	+	–	–	–	HTN	35
11	Female	36	+	–	–	+	–	–	+	HTN	23

BMI, Body mass index; *CAD,* coronary artery disease; *CKD,* chronic kidney disease; *DM,* diabetes mellitus; *HLP,* hyperlipidemia; *HTN,* hypertension; *PAD,* peripheral arterial disease; *Pt. No.,* patient number.

Supplementary Table II. Patency rate for patients who underwent endoscopic brachial-basilic arteriovenous fistula (AVF) creation

Follow-up, months	Primary, %	Primary assisted, %	Secondary, %
6	90 ± 10	90 ± 10	100
12	70 ± 20.7	90 ± 10	100
18	38 ± 34.1	77 ± 18.7	100

Data presented as mean ± standard error.

Supplementary Table III. Systemic review of all patients who underwent endoscopic-assisted arteriovenous fistula (AVF) creation

Investigator	Patients, No.	AVF type	Maturation success, %	Mean follow-up, months	Primary patency rate, %	Primary assisted rate, %	Secondary patency rate, %
Paul et al[22]	98	BB	NA	14	31.8	78.7	88.6
Leone et al[5]	20	BB	60	2	60	NA	73
Tordoir et al[4]	12	BB	NA	13.4	75	92	100
Hayakawa et al[24]	10	BB	100	6	60	NA	NA
Lin et al[23]	2	BB	100	NA	NA	NA	NA
Jeong et al[21]	16	BB; RC; BC	100	9	100	75	NA

BB, Brachial-basilic; *BC,* brachiocephalic; *NA,* not available; *RC,* radiocephalic.