ELSEVIER

Clinical Research

Use of Endoscopic Vein Harvest Yields Improved Outcomes in Popliteal Artery Aneurysm Repair

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Background: There is growing literature showing that endoscopic vein harvest (EVH) is safe, with excellent patency rates and decreased wound complications when treating infrainguinal occlusive disease. Our institution has performed EVH since 2003 with a dedicated team of providers specializing in endoscopic vein harvest. The purpose of this study was to evaluate major outcomes of EVH as an adjunct to standard, open operative repair of popliteal artery aneurysms.
Methods: We performed a 12-year retrospective single-institution chart review from January 2005 to December 2017, identifying all patients undergoing popliteal artery aneurysm repair with EVH. Primary outcomes were procedural technical success, operative time, wound complication, major morbidity, and freedom from amputation.
Results: A total 37 limbs (in 31 patients) received EVH popliteal artery aneurysm repair at an average age of 65.2 ± 10 years; 65% of the patients presented without symptoms or with claudication and 35% with rest pain or tissue loss. Coexisting aneurysm was present in 68% of patients: 49% had contralateral popliteal artery aneurysms and 19% had concurrent aortic aneurysms. Of 37 limbs, 33 (89%) were treated through a medial approach with aneurysm ligation, and 4 patients (11%) were treated through a posterior approach. The average vein size was 4.4 ± 1.1 mm, with 86% harvested by the ipsilateral great saphenous vein. Average operative time was 3.89 ± 0.82 hr, with a median hospitalization of 2 days and a median of 1 day of intravenous narcotics use. Only 2 patients (5.4%) had Szilagyi class-2 surgical site infections remedied with debridement and antibiotics. Kaplan–Meier data showed a 5-year primary patency of 82.3% and primary-assisted patency of 88.2%. Additionally, 30-day primary patency was 89.2% and primary-assisted patency of 97.3%.
Conclusions: EVH for popliteal aneurysmal disease provides a safe and efficacious means of popliteal artery aneurysm repair with shorter hospitalization, lower wound complication rates, and excellent long-term patency compared to standard open technique.

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INTRODUCTION

Popliteal artery aneurysms (PAA) are a rare condition affecting approximately 1 in 1,000 persons, but they constitute the most common lower-extremity aneurysm.[1] If allowed to progress, morbidity is significant and can include distal embolization, thrombosis, and rupture.[2] Risk of limb loss in symptomatic patients is reported to be between 20% and 59%.[3] Current recommendations are elective repair when aneurysm is > 2.0 cm in size, becomes symptomatic or mural thrombus is present.[3,4]

Traditional open surgical revascularization and endovascular stent grafting are currently used modalities for repair. The latter has become more common with development of covered stent grafting since its initial reported use in 1994.[5] Analysis of retrospective studies comparing open surgical revascularization and endovascular stenting have shown that stenting has increased rates of thrombosis and reintervention within 30 days compared to open surgery but similar long-term outcomes.[6] Over time, standard approaches depending on clinical and anatomic criteria have become more liberal. With open repair, 2 basic repair techniques exist, the medial and posterior approach. The former involves positioning the patient supine with proximal and distal ligation of the aneurysm and vein bypass. The latter necessitates prone positioning with a curved incision in the popliteal fossa and repair of the aneurysm with an interposition vein or graft. In the majority of cases, a vein graft is used.[7]

The development of endoscopic vein harvest (EVH) has afforded the ability to circumvent the morbidity associated with large incisions of traditional open vein harvest. Endoscopic, minimally invasive vein removal is heavily employed in the cardiac surgery literature and has been shown to have similar short-term patency and improved wound-related outcomes when compared to open vein harvest.[8] It has also been shown to be noninferior for infrainguinal bypass due to critical limb ischemia.[9] Our goal was to evaluate outcomes of popliteal artery aneurysm repair at our institution with minimally invasive endoscopic vein harvest technique. The primary outcomes examined during this study were primary patency and primary-assisted patency at 30 days and 5 years, and freedom from amputation. Secondary outcomes included length of stay, days of intravenous narcotic use, and wound complication.

METHODS

Data Collection and Patient Selection

This study is a retrospective 12-year review of all patients undergoing popliteal artery aneurysm repair using endoscopic vein harvest at St. Joseph Mercy Ann Arbor from January 2005 to December 2017. All popliteal artery aneurysm repairs were performed by board-certified vascular surgeons at this teaching institution with a resident or a fellow. Endoscopic vein harvests were performed by a dedicated team of physician assistants who work with both cardiac and vascular surgery. Demographic information collected included: age, gender and body mass index. Comorbid conditions included diabetes, smoking status, coronary artery disease, hypertension, and renal failure. Intraoperative variables included technical details, vein diameter, vein size, harvest site, and intraoperative complications. Postoperative variables included all clinical events including wound complications, length of hospital stay, intravenous narcotic use, and mobility status. This study was approved by the Institutional Review Board at Trinity Health Ann Arbor, Ann Arbor, Michigan.

PAA > 2 cm or those that were symptomatic were treated. All patients underwent computed tomography scan or angiography before surgery. The surgical technique was chosen after discussion between surgeon and patient. The medial approach entailed proximal and distal ligation with bypass grafting. The posterior approach involved aneurysmorrhaphy and reconstruction with interposition vein bypass.

Vein Harvest Technique

The choice of vein harvest site was based on ultrasound vein mapping obtained preoperatively. The average vein diameter was calculated using the measurements seen on vein mapping. All endoscopic vein harvests were performed by a dedicated team of cardiothoracic Physician assistants using a Maquet Hemapro system. The system utilizes CO2 inflation via a single port incision (Fig. 1A), and occasionally this incision site is also the site of our proximal anastomosis. A blunt-tipped dissector is attached to the end of a 5 mm endoscope and passed anterior and posterior to the vein to mobilize. A heat sealer C ring is then inserted to divide the branches and finish mobilizing the vein. A stab incision is then made to extract the vein while under direct visualization by the endoscope.

Statistical Analysis

Early (<30 days) results were analysed for mortality, graft thrombosis, and amputation rates. Freedom from amputation was defined as the avoidance of above-knee or below-knee amputation. Descriptive statistics are provided for the variables examined in this study. Five-year follow-up results including primary and primary-assisted patency, and freedom from amputation were analysed through creation of Kaplan–Meier curves. These Kaplan–Meier curves show the survival probability of patients over the time since their initial procedure until 1 of the outcomes of interest, or their final follow-up appointment. One patient was lost to follow-up and was removed from data analysis.

RESULTS

Demographic, and Anatomic Data

During a 12-year consecutive period, 31 patients (37 limbs) underwent popliteal artery aneurysm repair using EVH. Patients were predominantly male at 92% with a mean age of 65.2 ± 10 years. Approximately 81% had a smoking history and 89% had hypertension. Comorbidity data are shown in Table I. Mean aneurysm size was 3.25 ± 2.14 cm. Twenty-five of the patients had a coexisting aneurysm (67.6%) out of which contralateral popliteal artery aneurysm were 48.6% and Aortic arterial aneurysm in 18.9%. Sixteen percent of patients (6 out of 37) required emergent intervention while the remaining 84% (31 out of 37) were treated on an elective basis. The most common presenting symptom was claudication 46% (17 out of 37 patients), followed by rest pain 22% (8 out of 37) and tissue loss 14% (5 out of 37). Aneurysmal rupture occurred in 3 limbs and complete thrombosis occurred in 15 limbs (Table II).

Operative Details

The medial approach was used in 33 of 37 interventions (89%) and a posterior approach in 4 (11%). Of these who underwent the posterior approach, 3 out of the 4 required repositioning during the procedure. Vein characteristics are shown in Figure 2. Average vein diameter was 4.4 mm. The majority of the harvest sites were from the ipsilateral greater saphenous vein (31 out of 37 limbs). Of the remaining patients, 4 out of 37 limbs used contralateral greater saphenous vein, 1 used ipsilateral small saphenous vein, and 1 used ipsilateral upper extremity basilic vein. One patient of the 37 sampled underwent interposition graft while the others had a bypass procedure. The inflow vessel was either common or superficial femoral artery in 21 interventions and above knee popliteal artery in 15. The outflow vessel was below knee popliteal artery in 30, tibio-peroneal trunk in 2, posterior tibial in 3 and peroneal in 1 intervention, see Figure 3. The average operative time was 3.89 ± 0.82 hr.

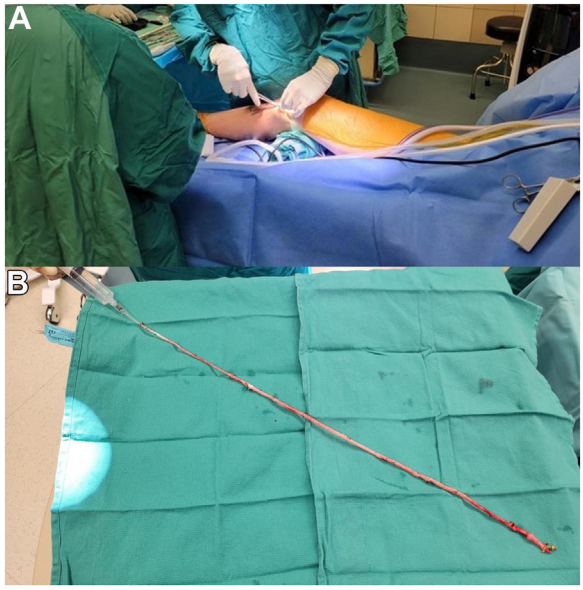

Fig. 1. (A) Single incision being made for endoscope to procure vein. **(B)** Successfully procured vein.

Postoperative Results

There were no intraoperative complications. Median postoperative length of stay was 2.5 days (Table III), and median days of intravenous narcotic use was 1.0. There were only 2 limbs with surgical site infections post operatively requiring minor incision and drainage. Incidentally, both limbs were in the same patient with Type-2 diabetes mellitus (HgbA1c of 11.4%), BMI of 35.5, and continued cigarette use. Surgical repair of the popliteal aneurysms in this patient were done by 2 separate surgeons. In both these cases the graft was unaffected, and patient recovered after drainage of small abscess and antibiotic treatment.

One patient required an endovascular balloon angioplasty 6 months from the initial operation. Due to diffuse sclerosis of the bypass graft cause severe stenosis 1 patient underwent ligation and creation of new bypass using PTFE graft 3 years after the initial surgery but subsequently this thrombosed and they required a below the knee amputation a year later. Two limbs required redo bypass due to occlusion, at 10 months and 64 months respectively.

Table I. Patient demographics

Variable	Statistics, no. (%)
Female	3 (8%)
Male	34 (92%)
Age, years, mean ± SD	65.297 (±10.036)
Prior Smoking history	30 (81%)
Smoking within last year	13 (35%)
Diabetes	11 (30%)
CAD	21 (57%)
History of Stroke	3 (8%)
HTN	33 (90%)
BMI Over 30	23 (66%)
ESRD	0 (0%)
Coexisting aneurysm, No. of patients	25 (68%)
Aortic	7 (19%)
Iliac	8 (22%)
Contralateral popliteal aneurysm	18 (49%)

Table II. Presenting symptoms and characteristics of popliteal artery aneurysm

Presentation/Treatment	Statistics, no. (%)
Asymptomatic	7 (19%)
Claudication	17 (46%)
Rest Pain	8 (24%)
Tissue Loss	5 (14%)
Emergent Repair	6 (16%)
Elective Repair	31 (84%)

Kaplan–Meier curves of freedom from amputation, primary patency and primary assisted patency can be seen in Figure 4. These data showed a 5-year primary patency of 82.3%, primary-assisted patency of 88.2%. Additionally, our 30-day primary patency was 89.2% and primary-assisted patency of 97.3%. The median length of last follow-up was 4.3 years. The 1-year mortality rate was 8.1%. Freedom from amputation rate of the surviving patients at the time of last follow-up was 97%.

DISCUSSION

With the advent of endovascular procedures for the treatment of infrainguinal arterial disease of all types, it is not surprising that it has been aggressively applied to repair of PAA. The minimal invasiveness leading to decreased wound complications and short hospital stay makes this approach very appealing. Given the rapidly improving stent graft designs and products, ongoing research will continue to monitor if the durability of open repair can be rationalized with decrease operative morbidity and pain.

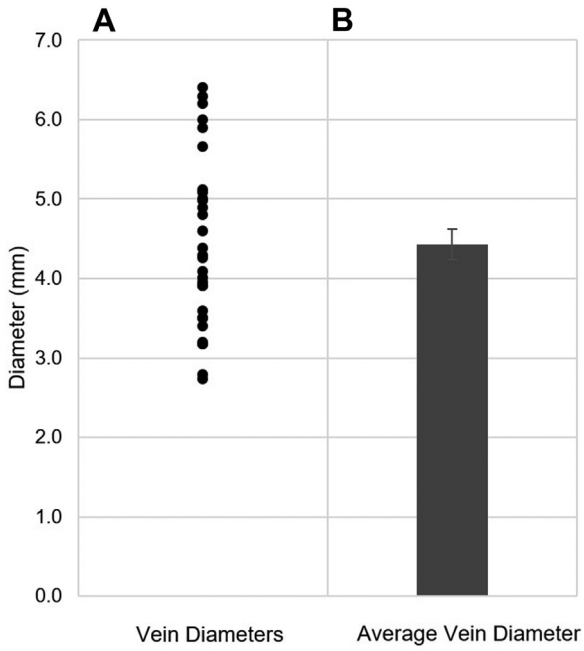

Fig. 2. Vein diameter. **(A)** scatter plot of vein diameter used in each surgery. **(B)** Average vein diameter (4.428 mm ± 1.072).

In our series, we feel we have achieved a ''sweet spot'' of short hospital length of stay, decreased wound complications, and improved surgical durability with the use of EVH.

Endoscopic vein harvest has been used in coronary artery bypass grafting since its advent in 1994 by Lumsden et al.[10] and has shown to decrease wound complications and hospital LOS.[11–13] EVH has been increasingly employed in infrainguinal bypass grafting for critical limb ischemia and has been shown to have similar lower wound complications.[12,13] Our institution has employed EVH for 20 years with a dedicated team of cardiothoracic and vascular PAs trained in harvesting and are readily available to assist in these operations. This series shows a median length of stay of 2.5 days and minimal use of IV narcotics (median 1 day). Reported LOS for open approach ranges from 4 to 6 days as previously mentioned.[14,15] Hunag et al. reported the open approach had a significantly longer length of stay at 4.2 days versus 1.9 days with an endovascular approach.[15] Average operative time was 3.89 ± 0.82 hr in our analysis. In 1 series, open repair had significantly longer operative times of 5.9 ± 1.5 hr when compared to endovascular stenting, 2.2 ± 0.9.[15] Our rate of wound complications are also lower (5.4%) than the 7.3% to 22% reported in literature for traditional open approaches.[14–16] In our results, wound complications were

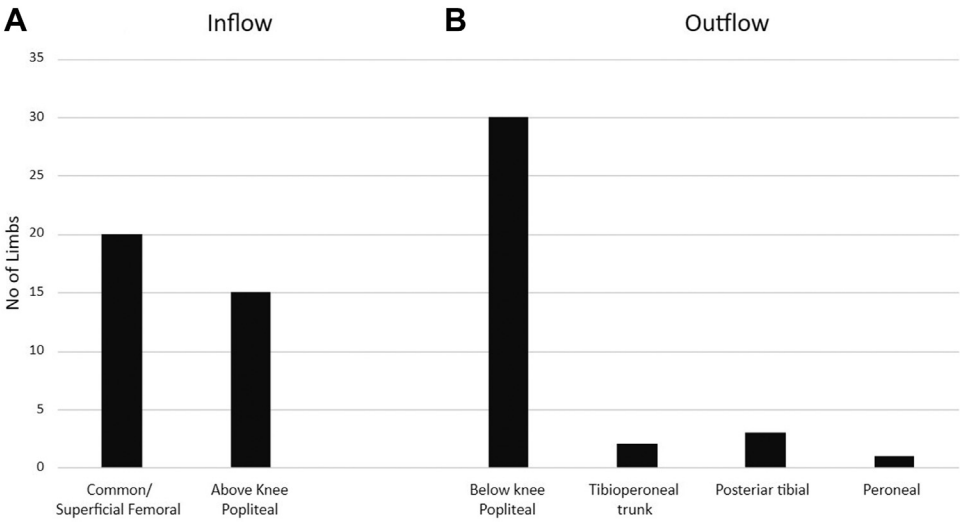

Fig. 3. Bypass characteristics. **(A)** inflow vessels used in each of the 37 cases. **(B)** outflow vessel used in each of the 37 cases.

accounted for in a single diabetic patient with staged, bilateral repairs.

Popliteal artery aneurysms are treated because of their poor natural history. Limb loss from complications of PAA has been observed in as high as 59% of patients.[3] The efficacy of surgical repair of PAA has been established by multiple previous studies.[17,18] Prior studies have failed to show difference in patency rate and amputation-free survival between prosthetic graft versus vein on univariate analysis. Previous studies examining long-term patency data after open popliteal aneurysm repair with traditional vein harvest techniques have shown a 5-year primary patency ranging from 69% to 93% while our study found a primary patency rate of 82.3% at 5 years.[19–24] A meta-analysis comparing 4,880 patients who underwent either elective open or endovascular PAA repair showed a primary patency at 3 years. 88.3% vs. 68.2%, respectively.[16] Our series showed excellent short-term results, with 30-day primary patency was 89.2% (34 out of 37 limbs), primary-assisted patency 97.3% (36 out of 37 limbs), and longer-term amputation rate of 2.7% (1 out of 37 limbs).

Previous reports have shown that approximately 67% of PAA patients presented with symptoms of limb ischemia. Univariate analysis from Dorweiler et al., looking at open PAA repair, suggests slightly inferior outcomes in this subgroup with limb salvage rate of 91.5% at 5 years versus 98% for elective cases.[7] No significant difference in graft patency was reported. Multivariate analysis within the series favoured the posterior approach over medial. In our series a much higher rate, 81%, presented with symptoms of limb ischemia with 16% requiring emergent repair. Another recent meta-analysis suggests that the posterior approach may be superior to medial with regards to primary-assisted patency at 30 days and long-term primary patency, but equivalent in regard to nerve damage, 30-day complications, 30-day limb loss, and 30-day primary patency.[1] Despite these ongoing modern controversies on open operative approach, it is hard to determine whether venous conduits significantly affect the results. Our posterior approach numbers were not sufficient to make a valid comparison as only 10.8% of patients underwent repair via this approach. It would be beneficial to evaluate the 2 approaches with use of endoscopic vein harvest and assess if it has any effect on patency rates.

This study does have a few limitations including the retrospective nature of the study, small sample size, and limited long-term data. While it would be ideal to perform a randomized control trial comparing EVH and open-vein harvest given the

Table III. Major postoperative outcomes

Variable	Outcomes
Surgical Site infection requiring I&D	2 (5.4%)
Redo Bypass	2 (5.41%)
Amputation	1 (2.7%)
Time in OR	3.89 (±0.82)
Length of Stay (days), median	2
Length of IV Narcotic use (days), median	1

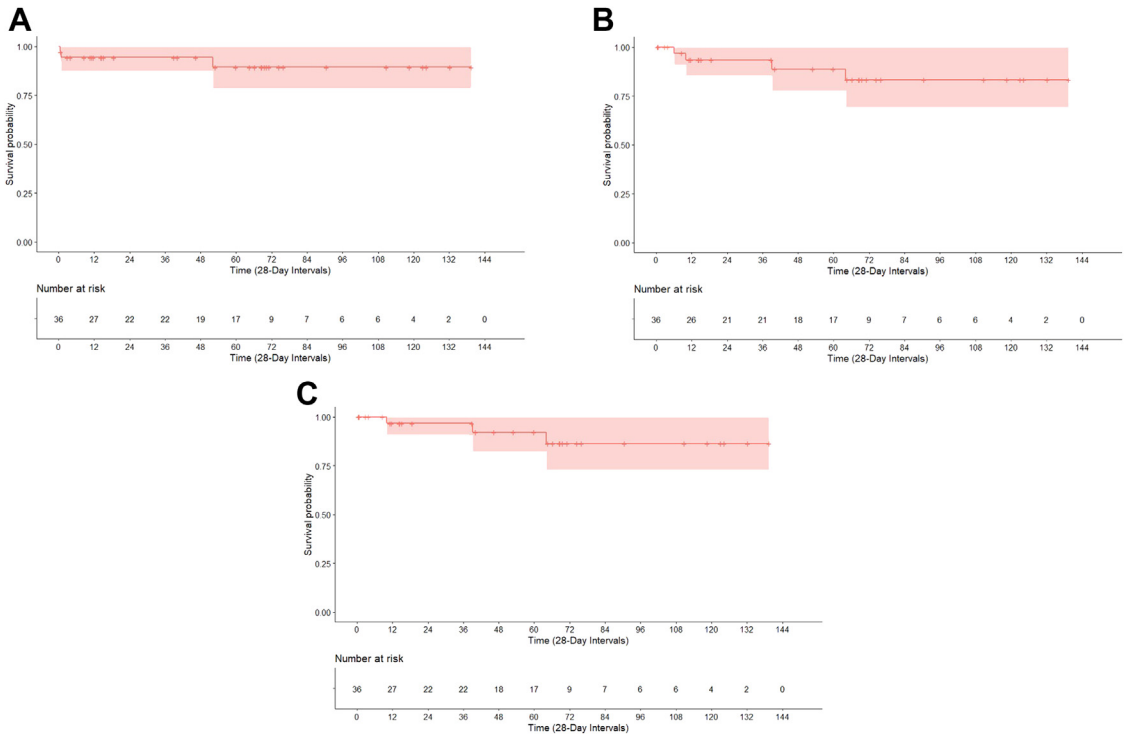

Fig. 4. Kaplan—Meier curves showing freedom from amputation, primary patency and primary assisted patency. **(A)** Freedom from amputation (Time from bypass to amputation or death). **(B)** Primary patency (Time from bypass creation to bypass stenosis, thrombosis or failure requiring intervention). **(C)** Primary-assisted patency (Time from bypass creation to thrombosis or bypass failure requiring intervention).

uncommon nature of popliteal artery aneurysm, it would be difficult to obtain a sufficient number of patients to allow for adequate comparison. As mentioned, this is an uncommon pathology, and our sample size of this study was limited. While our study size was limited, we feel it was sufficient to observe the efficacy of EVH. Finally, as this was a retrospective study, we are limited to the data available and some of the patients were lost to long term follow-up, though we were able to derive estimated 5-year patency data through statistical analysis and creation of Kaplan—Meier curves (Fig. 4).

CONCLUSION

This retrospective review evaluated both short term and long term outcomes following EVH in open popliteal artery aneurysm repair. Our study has shown that EVH has low morbidity and without compromising efficacy. EVH allows for short length of hospital stay, few wound complications, and less narcotic use without sacrificing patency. EVH is an excellent alternative to open harvest in the repair of popliteal artery aneurysms at institutions with routine dedicated endoscopic harvest teams.

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