

Mid-term outcomes of endovascular popliteal artery aneurysm repair

Michael A. Curi, MD,^a Patrick J. Geraghty, MD,^a Oscar A. Merino, MD,^b Ravi K. Veeraswamy, MD,^a Brian G. Rubin, MD,^a Luis A. Sanchez, MD,^a Eric T. Choi, MD,^a and Gregorio A. Sicard, MD,^a
St. Louis, Mo; and Palma de Mallorca, Spain

Objective: This study documents mid-term outcomes of a series of endovascular popliteal aneurysm repairs compared with concurrent results of open surgical repair.

Methods: A retrospective chart review was done of all popliteal artery aneurysm repairs since January 1, 2000. Patency was defined as continued presence of palpable pulses or maintenance of postoperative ankle-brachial index $\pm$ 0.15. Statistical methods included χ^2 , *t* test, Fisher's exact test, and Kaplan-Meier plots with log-rank comparison.

Results: A total of 56 popliteal artery aneurysm repairs were performed. All endovascular popliteal aneurysm repairs (EVPAR, *n* = 15) were performed using Viabahn endoprostheses. Patients with open repair (OR, *n* = 41) underwent surgical bypass and aneurysm exclusion with great saphenous vein (*n* = 26), short saphenous vein (*n* = 3), or polytetrafluoroethylene (*n* = 12), through either a medial (*n* = 28) or posterior (*n* = 13) approach. All urgent cases received open repair. Technical success was 100% in both groups. Mean follow-up was 16.5 ± 3 months (range, 0.5 to 56 months). Aneurysm size, location, and outflow were similar between groups. Primary patency, secondary patency, and survival did not differ between groups. Endoleaks were observed in three (20%) of 15 endovascular cases, and type I and III endoleaks were treated with additional endografts.

Conclusion: To our knowledge, this represents the largest United States series of EVPAR to date. Early mid-term results of elective endovascular repair of popliteal artery aneurysms are encouraging. Further studies are warranted to define optimal indications for EVPAR and to generate long-term outcomes for this technique. (J Vasc Surg 2007;45:505-10.)

Popliteal artery aneurysm (PAA) is the most commonly encountered peripheral arterial aneurysm. Owing to high rates of thromboembolic complications, PAA confers significant risk of limb loss, and surgical exclusion has been advocated for aneurysms displaying mural thrombus or >2 cm in diameter. Marin et al¹ first described the use of a covered stent as a means of PAA repair in 1994. Although early reports detailed the technical feasibility of endovascular popliteal aneurysm repair (EVPAR), outcomes with first-generation devices were poor.² The subsequent introduction of expanded polytetrafluoroethylene (ePTFE)-lined nitinol stents, such as the Viabahn endoprosthesis (W. L. Gore & Assoc, Inc, Flagstaff, Ariz), has renewed interest in the potential application of these devices to EVPAR.

This report reviews our 6-year experience with both EVPAR and open repair (OR) of PAAs at Washington University. Indications, technique, and early mid-term results for our EVPAR experience are compared with contemporaneous OR outcomes.

METHODS

A retrospective review was performed of all patients who underwent PAA repair at Washington University from

January 2000 to March 2006. The study design and protocol was approved by the institutional Human Studies Committee. Hospital records, clinic notes, and vascular laboratory reports were used to compile a database of all PAA repairs. Procedures were grouped by method of repair (EVPAR vs OR). The two groups were then compared, with graft patency as the primary end point. Secondary end points included complication rates, frequency of endoleak, and overall survival.

Indications, complications, endoleak characterization, patency rates, and survival are reported in accordance with recommended standards.^{3,4} *Symptomatic* patients included those experiencing claudication, rest pain, embolic stigmata, or venous hypertension attributed to the PAA. *Urgent* procedures were those undertaken after the minimum necessary preoperative studies; in general, urgent operation was dictated by a perceived limb threat. *Outflow* was characterized as the number of tibial vessels intact from origin to ankle. *Patency* was defined as continued presence of palpable pulses or maintenance of a postoperative ankle-brachial index (ABI) with a change of <0.15 .

Statistical analysis. Statistical analysis was performed using SPSS software (SPSS, Inc, Chicago, Ill) for Windows (Microsoft Corp, Redmond, Wash). Patient characteristics, indications, and complications were compared using Pearson χ^2 analysis. Mann-Whitney tests were used for nonparametric comparison of means. Patency and survival rates were compared using Kaplan-Meier plots and log-rank analysis. Statistical significance was accepted at $P < .05$.

Endovascular popliteal aneurysm repair technique. EVPAR was accomplished using Viabahn endoprostheses

From Washington University School of Medicine,^a and Son Dureta Hospital.^b
Competition of interest: none.

Presented at the Sixteenth Annual Winter Meeting of the Peripheral Vascular Surgery Society, Park City, Utah, Jan 26-29, 2006.

Correspondence: Patrick J. Geraghty, MD, Washington University, Department of Surgery, 660 S Euclid Ave, Campus Box 8109, St. Louis, MO 63110 (e-mail: geraghtyp@msnotes.wustl.edu).

0741-5214/\$32.00

Copyright © 2007 by The Society for Vascular Surgery.

doi:10.1016/j.jvs.2006.09.064

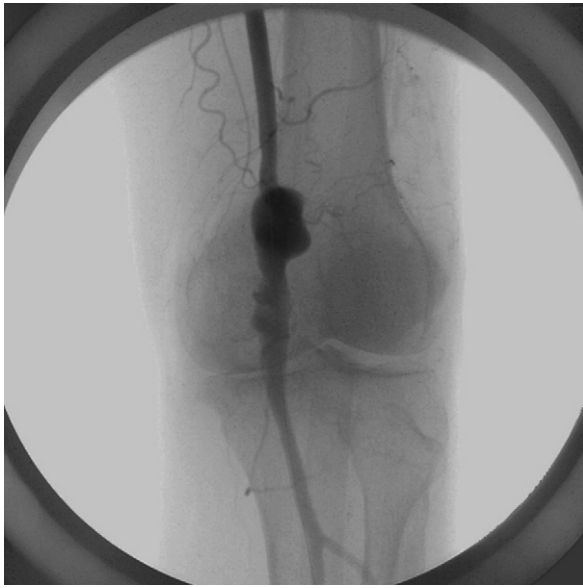


Fig 1. Initial angiogram shows the left popliteal artery aneurysm.



Fig 2. Under roadmap guidance, the Viabahn endoprosthesis is positioned.

to exclude the aneurysm sac. Viabahn endografts are available in diameters of 5 to 13 mm, and lengths of 2.5 to 15 cm. The introducer sheath size required for graft placement ranges from 8F to 12F. Computed tomography (CT) angiography was the favored preoperative imaging modality.

Although rigid guidelines for EVPAR technique were not established at the outset of our experience, proximal and distal landing zones of nonaneurysmal artery of ≥ 2 cm length were sought, with the distal terminus of the endograft(s) not extending beyond the popliteal artery. Endografts were oversized 10% to 15% relative to the landing zones. When sequential endografts were required to achieve aneurysm exclusion, 2 to 3 cm of overlap between endografts was generally used. Overlapping endografts differed by no more than 2 mm in diameter, because greater differences in diameter may lead to longitudinal pleating of the larger graft, with loss of seal.

Arterial access was accomplished by a mini-cutdown to the common femoral or proximal superficial femoral artery, percutaneous antegrade approach, or percutaneous retrograde crossover approach. Because the sheath sizes required for repair proscribe the use of most closure devices, the small cutdown permits placement of a transverse mattress suture at the intended antegrade arterial puncture site. Intraoperative imaging of landing zones with a 0.018-inch guidewire-compatible intravascular ultrasound probe (Volcano, Rancho Cordova, Calif) was frequently used to complement intraoperative angiography. Figs 1, 2, 3, and 4 show intraoperative angiograms from a representative EVPAR procedure.

RESULTS

A total of 43 patients underwent PAA repair in 56 limbs. Of these, 30 patients underwent OR in 41 limbs, and



Fig 3. The endograft is deployed.

13 patients underwent EVPAR in 15 limbs. Patient characteristics are summarized in Table I. The patients treated for PAA were primarily men in the seventh and eighth decades of life. Patient groups differed only in respect to age. The EVPAR group was a mean 7 years older than the OR group (75 ± 1.6 vs 68 ± 2.4 , $P < .05$). Rates of comorbidities were high and similar between groups (Table I). A contralateral PAA was present in 70% of patients.

A significantly higher percentage of OR cases (54%) were performed for symptomatic patients vs EVPAR (13%;

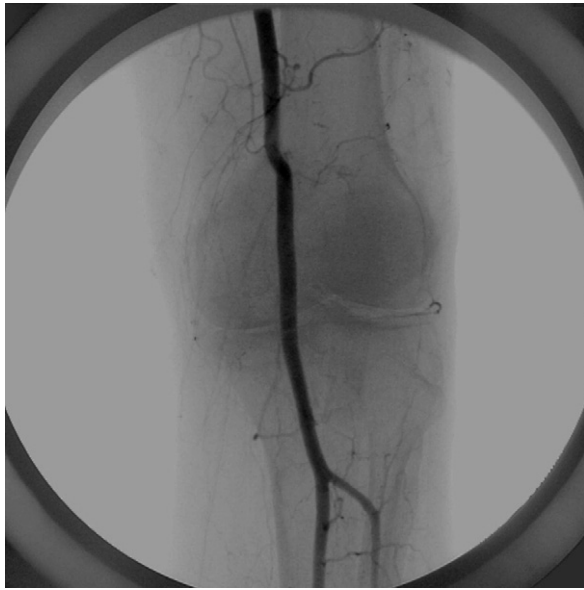


Fig 4. Completion angiogram demonstrates exclusion of the popliteal artery aneurysm.

Table I. Patient demographics and risk factors

	EVPAR (%) [*] (n = 15)	OR (%) [*] (n = 41)
Age, years	75 ± 1.6	68 ± 2.4 [†]
Male	93	93
Hypertension	67	73
Coronary disease	60	54
Previous MI	47	22
Smoker	45	74
COPD	7	23
Diabetes	13	27
History of AAA	53	37
Bilateral PAA	67	79

EVPAR, Endovascular popliteal aneurysm repair; OR, open repair; MI, myocardial infarction; COPD, chronic obstruction pulmonary disease; AAA, abdominal aortic aneurysm; PAA, popliteal aortic aneurysm.

^{*}Data are presented % for categoric variables and mean ± SEM for continuous variables.

[†]P ≤ .05.

P < .05), and the five urgent cases received OR (12% vs 0% EVPAR, P = NS). Anatomic variables related to aneurysm size and tibial outflow vessels (Table II) did not differ significantly between groups. Of note, approximately one third of patients in each group had single vessel runoff at the time of surgery.

All EVPAR cases were performed using the Viabahn endoprosthesis. Open cases (n = 41) underwent surgical bypass and aneurysm exclusion with great saphenous vein (n = 26), short saphenous vein (n = 3), or PTFE (n = 12) through either a medial (n = 28) or posterior (n = 13) approach. Outflow thrombectomy or thrombolysis was performed in eight (15%) cases and did not differ between groups (7% EVPAR vs 17% OR, P = NS). In two EVPAR

Table II. Surgical indications and anatomy

	EVPAR (n = 15)	OR (n = 41)
Median diameter (cm)	2.5	2.6
Symptomatic (%)	13	54 [*]
Urgent (%)	0	12
Runoff vessels (%)		
1	33	34
2	33	27
3	33	39

EVPAR, Endovascular popliteal aneurysm repair; OR, open repair.

^{*}P ≤ .05.

Table III. Treatment data

	EVPAR, n (%) (n = 15)	OR, n (%) (n = 41)
Outflow thrombolysis	1 (7)	7 (17)
Proximal terminus		
CFA	0	8 (20)
SFA	14 (93)	12 (29)
Popliteal	1 (7)	21 (51)
Distal terminus		
Popliteal	15 (100)	36 (88)
Tibial	0	5 (12)
LOS (mean, days)	1	5 [*]
Post-op warfarin	0%	22% [*]
Post-op clopidogrel	87%	11% [*]

EVPAR, Endovascular popliteal aneurysm repair; OR, open repair; CFA, common femoral artery; SFA, superficial femoral artery; LOS, length of stay. ^{*}P ≤ .05.

procedures (13%), dilation of stenosis adjacent to the PAA was performed before endograft delivery. The dilated area was subsequently covered by the deployed endograft. Technical success was 100% in both groups.

Although no EVPAR patients were anticoagulated, 22% of the OR group was discharged on warfarin therapy (P < .05). Indications for warfarin therapy included long-term treatment of intracranial atherosclerosis or atrial fibrillation (44%) and a new diagnosis of hypercoagulable state (22%). Use of warfarin therapy did not appear to influence patency rates. Nearly all EVPAR patients (87%) were treated with clopidogrel, compared with 11% of the OR group (P < .05). Mean length of stay was significantly shorter in the EVPAR group (0.9 ± 0.2 days vs 4.9 ± .5 days). Comparative treatment data are summarized in Table III, and additional data on EVPAR are provided in Table IV.

Major complications occurred in 7% of patients in both groups. One EVPAR patient experienced femoral puncture site bleeding that required suture repair; this patient had received percutaneous antegrade arterial access with 9F sheath placement. Wound abscesses developed in three OR patients that required intervention, and one of these infections resulted in sepsis and death.

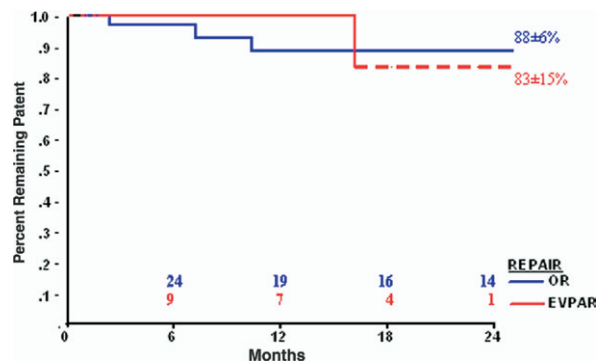
Mean follow-up was 14 ± 3 months for EVPAR and 17 ± 3 months for OR (total mean, 16.5 ± 3 months; range, 0.5 to 56 months). At 24 months, primary patency

Table IV. Intraoperative endovascular popliteal aneurysm repair variables

Variable	N (%) *
Sheath size (median, range)	10F (8F-12F)
Access	
Cutdown - antegrade	11 (73)
Percutaneous - antegrade	3 (20)
Percutaneous retrograde	1 (7)
Stent grafts used (n)	
1	10 (67)
2	2 (13)
3+	3 (20)
Endograft size (mm)	8 (6-11)
IVUS imaging	6 (40)

IVUS, Intravascular ultrasound.

*Data are presented as n (%) for categoric variables and median (range) for continuous variables.

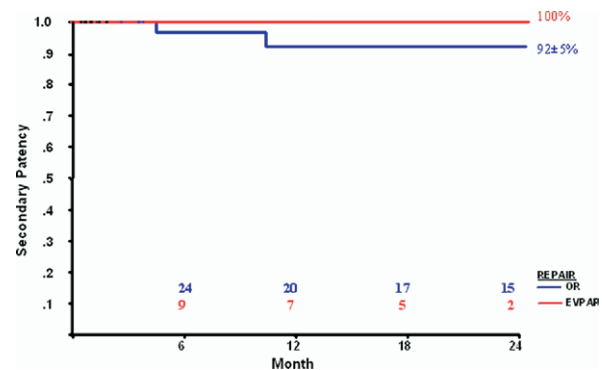
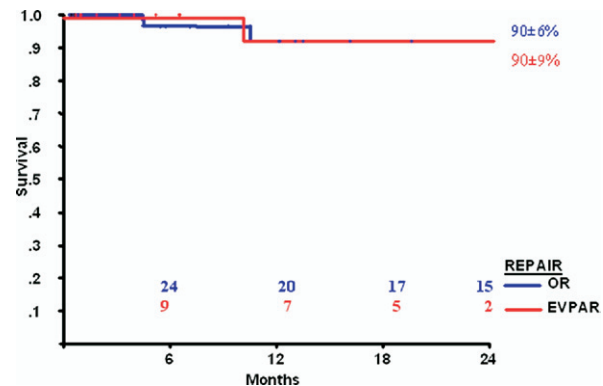
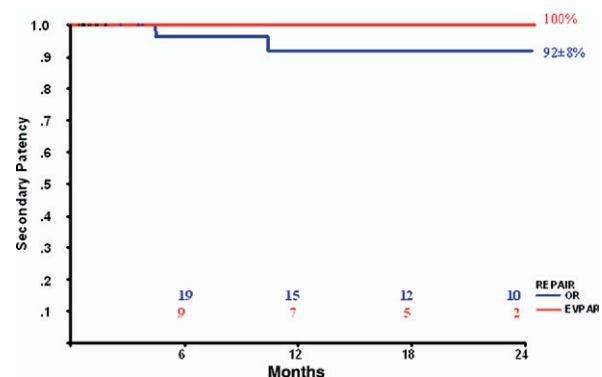
**Fig 5.** Kaplan-Meier analysis of primary patency of open repair (OR) compared with endovascular popliteal aneurysm repair (EVPAR). Broken lines indicate SEM > 10%.

($83\% \pm 15\%$ vs $88\% \pm 6\%$, $P = \text{NS}$), secondary patency (100% vs $92\% \pm 5\%$, $P = \text{NS}$), and survival ($90\% \pm 9\%$ vs $90\% \pm 6\%$, $P = \text{NS}$) did not differ between the EVPAR and OR groups, respectively (Figs 5, 6, and 7). Comparison of only electively performed repairs (Fig 8) also demonstrated no difference in secondary patency at 24 months between OR ($92 \pm 8\%$) and EVAR (100%).

Endoleaks have been detected in three (20%) of 15 EVPAR patients. A combined type I and type III endoleak owing to endograft migration was found in one patient. This was resolved by deployment of additional endografts. Type II endoleaks were found in two additional patients and were followed up conservatively, with shrinkage of one PAA and no change in the other.

DISCUSSION

Acute ischemia is the first presenting symptom in 20% to 50% of patients with PAA. Continued observation of asymptomatic PAA is associated with complication rates of 15% to 25% at 1 year and 60% to 75% at 5 years.^{5,6} To prevent the limb loss and morbidity engendered by thromboembolic complications, early repair of asymptomatic aneurysms exceeding >2 cm or containing mural thrombus is

**Fig 6.** Kaplan-Meier analysis of secondary patency of open repair (OR) compared with endovascular popliteal aneurysm repair (EVPAR).**Fig 7.** Kaplan-Meier analysis of patient survival after undergoing open repair (OR) compared with endovascular popliteal aneurysm repair (EVPAR).**Fig 8.** Secondary patency of endovascular repairs (EVPAR) compared with only the elective open repairs (OR) showing no significant difference between groups.

recommended.⁷ This has traditionally been accomplished with elective open surgical repair of PAA and has yielded 5-year secondary patency rates of 60% to 80%.⁸⁻¹³ Factors affecting patency and limb salvage include the number of

patent tibial outflow vessels, urgency of repair, and conduit choice.

Although open surgical repair effectively mitigates the risk of thromboembolic complication, investigators have sought to adapt endovascular technology to PAA repair. Howell et al¹⁴ repaired 13 aneurysms using the Wallgraft endoprosthesis (Boston Scientific, Natick, Mass), but thrombosis was detected in 31% at 12 months' follow-up.¹⁴

More recently, Tielliu et al¹⁵ reported a series of 57 cases in which EVPAR was performed using Viabahn stent grafts. Technical success was 100%. Primary and secondary patency rates at 2 years were 77% and 87%. Acute ischemia was the indication for PAA repair in five (8.8%) of 57, and only one third of patients received postprocedural antiplatelet or anticoagulation therapy. The only variable found to be associated with success was treatment with clopidogrel.

Antonello et al¹⁶ published a prospective randomized trial comparing 15 OR and 15 EVPAR in patients with PAA $\geq$ 2 cm, adequate proximal and distal landing zones, and acceptable outflow.¹⁶ These patients were significantly younger than in the current series, with a mean age of 63, and all were suitable candidates for open repair. With primary and secondary patency rates of 87% and 100% at 24 months, the results in this randomized group were remarkably similar to those in the current report.¹⁷

CONCLUSION

This retrospective review demonstrates encouraging mid-term results of EVPAR in a small group of selected patients. Reasonable patency rates were achieved, and no instances of limb loss occurred. However, several weaknesses of the study necessitate caution at this juncture:

1. *Study design and duration.* As noted, the relatively low numbers of patients and early mid-term follow-up do not permit us to forecast long-term outcomes.
2. *Absence of standardized inclusion and exclusion criteria.* The recommendation for EVPAR was ultimately made at the surgeon's discretion, although patient variables (other than advanced age) favoring the use of EVPAR included absent or inadequate saphenous vein conduit (33%), simultaneous or recent other major surgery (27%), and symptomatic contralateral lower extremity occlusive disease (20%). All urgent cases and most symptomatic cases underwent open repair, likely reflecting reluctance on the part of our surgeons to attempt this new technique on the subset of patients at greatest risk for limb loss. Therefore, although the patency outcomes in Figs 5 to 8 are of interest, the heterogeneous nature of patient groups studied mandates caution in their interpretation.

Anatomic contraindications to EVPAR have not been well defined, but landing zones diameters >12 mm and <4 mm would not be expected to offer adequate seal with the available Viabahn endoprostheses. Likewise, wide variation in the diameters of the proximal and distal landing zones may preclude an appropriate telescoping of grafts, particularly when the length of

aneurysm to be covered is short. Finally, within our group, predicted terminus of repair within a tibial artery, or covering the orifice of a patent tibial artery, is felt to negate consideration for EVPAR.

3. *Variables related to procedure and endograft.* Variables such as the length of the landing zone and overlap between components were not standardized; indeed, the appropriate lengths in each instance have yet to be rigorously established. Such variables can affect endograft performance: in the solitary EVPAR that developed type I and III endoleaks, a review of radiographic images suggests that the initial distal landing zone and overlap between endograft components may have been as little as 1 cm in length. Long-term durability of the Viabahn endograft in popliteal aneurysms, including the rate and clinical significance of nitinol component fractures, remains unknown.

The current series should not be misrepresented as an endorsement of the unrestricted use of EVPAR. Further studies will be needed to define the optimal role and candidates for this technique.

AUTHOR CONTRIBUTIONS

Conception and design: MA, PG, ET

Analysis and interpretation: MA, PG, GS

Data collection: MA, PG, OM, RV

Writing the article: MA, PG, RV

Critical revision of the article: MA, PG, OM, RV, BG, LS, EC, GS

Final approval of the article: MA, PG, OM, RV, BG, LS, EC, GS

Statistical analysis: MA, OM, PG

Obtained funding: Not applicable

Overall responsibility: PG

REFERENCES

1. Marin ML, Veith FJ, Panetta TF, Cynamon J, Bakal CW, Suggs WD, et al. Transfemoral endoluminal stented graft repair of a popliteal artery aneurysm. *J Vasc Surg* 1994;19:754-7.
2. Gerasimidis T, Sfyroeras G, Papazoglou K, Trellopoulos G, Ntinis A, Karamanos D. Endovascular treatment of popliteal artery aneurysms. *Eur J Vasc Endovasc Surg* 2003;26:506-11.
3. Chaikof EL, Blankensteijn JD, Harris PL, White GH, Zarins CK, Bernhard VM, et al. Reporting standards for endovascular aortic aneurysm repair. *J Vasc Surg* 2002;35:1048-60.
4. Rutherford RB, Baker JD, Ernst C, Johnston KW, Porter JM, Ahn S, et al. Recommended standards for reports dealing with lower extremity ischemia: revised version. *J Vasc Surg* 1997;26:517-38.
5. Whitehouse WM Jr, Wakefield TW, Graham LM, Kazmers A, Zelenock GB, Cronenwett JL, et al. Limb-threatening potential of arteriosclerotic popliteal artery aneurysms. *Surgery* 1983;93:694-9.
6. Dawson I, Sie R, van Baalen JM, van Bockel JH. Asymptomatic popliteal aneurysm: elective operation versus conservative follow-up. *Br J Surg* 1994;81:1504-7.
7. Stiegler H, Mendler G, Baumann G. Prospective study of 36 patients with 46 popliteal artery aneurysms with non-surgical treatment. *Vasa* 2002;31:43-6.
8. Pulli R, Dorigo W, Troisi N, Innocenti AA, Pratesi G, Azas L, et al. Surgical management of popliteal artery aneurysms: which factors affect outcomes? *J Vasc Surg* 2006;43:481-7.

9. Carpenter JP, Barker CF, Roberts B, Berkowitz HD, Lusk EJ, Perloff LJ. Popliteal artery aneurysms: current management and outcome. [See comment]. *J Vasc Surg* 1994;19:65-72; discussion 72-3.
10. Aulivola B, Hamdan AD, Hile CN, Sheahan MG, Skillman JJ, Campbell DR, et al. Popliteal artery aneurysms: a comparison of outcomes in elective versus emergent repair. *J Vasc Surg* 2004;39:1171-7.
11. Elsmann BH, van Rijn AB. In-situ saphenous vein bypass graft for popliteal artery aneurysm. *Neth J Surg* 1991;43:14-6.
12. Dawson I, van Bockel JH, Brand R, Terpstra JL. Popliteal artery aneurysms. Long-term follow-up of aneurysmal disease and results of surgical treatment. *J Vasc Surg* 1991;13:398-407.
13. Michaels JA, Galland RB. Management of asymptomatic popliteal aneurysms: the use of a Markov decision tree to determine the criteria for a conservative approach. *Eur J Vasc Surg* 1993;7:136-43.
14. Howell M, Krajcer Z, Diethrich EB, Motarjeme A, Bacharach M, Dolmatch B, et al. Wallgraft endoprosthesis for the percutaneous treatment of femoral and popliteal artery aneurysms. *J Endovasc Ther* 2002;9:76-81.
15. Tielliu IF, Verhoeven EL, Zeebregts CJ, Prins TR, Span MM, van den Dungen JJ. Endovascular treatment of popliteal artery aneurysms: results of a prospective cohort study. [See comment]. *J Vasc Surg* 2005;41:561-7.
16. Antonello M, Frigatti P, Battocchio P, Lepidi S, Cognolato D, Dall'Antonia A, et al. Open repair versus endovascular treatment for asymptomatic popliteal artery aneurysm: results of a prospective randomized study. *J Vasc Surg* 2005;42:185-93.
17. Lowell RC, Gloviczki P, Hallett JW Jr, Naessens JM, Maus TP, Cherry KJ Jr, et al. Popliteal artery aneurysms: the risk of nonoperative management. *Ann Vasc Surg* 1994;8:14-23.

Submitted Jun 29, 2006; accepted Sep 13, 2006.

CME Credit Now Available to JVS Readers

Readers can now obtain CME credits by reading selected articles and correctly answering multiple choice questions on the Journal website (www.jvascsurg.org). Four articles are identified in the Table of Contents of each issue and 2 questions for each are posted on the website. After correctly answering the 8 questions, readers will be awarded 2 hours of Category I CME credit.