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Original Article

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Outcomes of open surgery in popliteal artery aneurysms: Five years of experience in a single center

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ABSTRACT

Objectives: The aim of this study was to review and share the results of patients with popliteal artery aneurysms (PAAs) who underwent open surgery in our clinic.

Patients and methods: This single-center, retrospective, descriptive study was performed on 32 PAA patients (22 males, 10 females; mean age: 63±14 years; range, 52 to 76 years) surgically treated at our clinic between January 2015 and January 2020. The preoperative data, surgical approach, procedure performed, and graft selection were recorded. Postoperative early mortality and morbidity and one-year patency were evaluated.

Results: As a result of bilateral aneurysms in five patients, a total of 37 PAA operations were performed. Ten patients were asymptomatic, and two of these patients had bilateral PAA. Twenty-five (67.6%) limbs were symptomatic, including 14 (37.8%) with acute limb ischemia and two (5.4%) ruptured PAAs. Saphenous grafts were used in 21 (56.7%) patients, polytetrafluoroethylene in 14 (37.8%), and Dacron grafts in two (5.4%) limbs. The median intensive care unit stay was one day (range, 0 to 3 days), and the median hospitalization period was five days (range, 3 to 11 days). Hematoma was observed in two limbs, wound infection in two limbs, and superficial wound infection in two limbs. The primary patency rate was 97.2, 94.4, and 94.44% at 1, 6, and 12 months, respectively. The secondary patency rate was 100% in all follow-ups.

Conclusion: Thorough preoperative imaging and meticulous surgical technique are crucial for a better outcome after open repair.

Keywords: Medial approach, open repair, popliteal aneurysm, popliteal artery, vascular surgery.

An increase of more than 50% in the diameter of the popliteal artery is defined as a popliteal artery aneurysm (PAA).[1] Although the incidence of PAA is low (0.01%), it accounts for more than 70% of peripheral artery aneurysms.[2] Popliteal artery aneurysms are usually observed in individuals over 65 years and often occur bilaterally. A total of 40 to 60% of PAAs are accompanied by aneurysms in other arteries.[2] Although patients with PAA may be asymptomatic, more than half present with symptoms, often with acute limb ischemia secondary to thromboembolic complications.[3] Deep vein thrombosis or nerve compression with mass effects are rare symptoms.[4] High morbidity and limb loss are associated with acute limb ischemia.[2,5] Observational studies have also demonstrated that the probability of asymptomatic PAAs becoming symptomatic is 70% within five years.[1,4]

Today, open surgical treatment and endovascular treatments are widely used in the treatment of PAAs. In open surgery, medial and posterior approaches are applied according to the location of the aneurysm.[5,6] With the recent development in stent technology and the increase in interventional procedures, interventional treatment has also begun to be applied in PAAs.[7,8]

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There have been many studies on the diagnosis and treatment of PAA.[8-14] The mortality and morbidity rates in the surgical intervention of PAAs are admissible.[8,9] Certainly, the impact of the patient's history and the chosen surgical method on reintervention and adverse events should be considered in detail. The aim of this study was to review and share the results of patients with PAA who underwent open surgery in our clinic.

PATIENTS AND METHODS

This single-center, retrospective, descriptive study was performed on 32 PAA patients (22 males, 10 females; mean age: 63±14 years; range, 52 to 76 years) surgically treated at the Bakırköy Dr. Sadi Konuk Training and Research Hospital between January 2015 and January 2020. The patients enrolled in the study underwent open surgery, and those who were operated on with a posterior approach were not included. All subjects were evaluated with computed tomography (CT) angiography. The patients were preoperatively evaluated with CT to plan the course of surgery, establish the size of the aneurysm, and choose the correct artery for the distal anastomosis. The demographic data (age, sex, obesity, smoking, and additional illness), preoperative medications, and laboratory values of the subjects were collected (Table 1).

All patients were preoperatively evaluated with CT angiography. Preoperative arteriograms were reviewed, and the infrapopliteal arterial anatomy was classified according to the number of patent tibioperoneal vessels that were continuous from their origin to the ankle, ranging from 0 to 3. A popliteal artery diameter greater than 2 cm was considered an indication for treatment. Surgery was planned for symptomatic patients. In asymptomatic patients, surgery was indicated in patients with a popliteal artery diameter of >2 cm, rapid increase in the diameter in the six-month follow-up, or more than 50% thrombus in addition to the aneurysm. All elective patients were also evaluated with coronary angiography for coronary artery disease.

The admission symptoms of the patients, the dimensions of the preoperative aneurysm, and other accompanying aneurysms were evaluated. Computed tomography of the abdomen and lower extremities was routinely performed in all patients. However, when an aneurysm was detected, carotid and thoracic CT were

Table 1. Demographic and preoperative data

	n	%	Mean±SD	Min-Max
All patients	35	100		
Male	22	68.7		
Hypertension	23	71.8		
Hyperlipidemia	18	56.2		
Diabetes mellitus	20	62.5		
Smoking	24	75		
Obesity (>35 kg/m^2)	3	9.3		
Chronic kidney failure	2	6.2		
Malignancy	1	3.1		
Atrial fibrillation	3	9.3		
Chronic obstructive pulmonary disease	4	12.5		
Coronary artery disease	6	18.7		
Behçet's syndrome	4	12.5		
Age (year)			63±14	52-76
Hematocrit (%)			34.7±4.8	23.3-42.3
Hemoglobin (g/dL)			12.9±4.8	6.2-14.5
Platelet (10^6/uL)			285.6±137.1	187.000-432.000
Preoperative medication				
Statin	13	40.6		
Antiagregan	17	53.1		
Anticoagülan	7	21.8		
Antihypertansive	24	75		
Beta blockers	19	59.3		

SD: Standard deviation.

also performed. Stenosis or occlusion during follow-up was considered as the endpoint. The preoperative surgical approach, procedure performed, and graft selection were recorded. Postoperative early mortality and morbidity and one-year patency were evaluated.

Surgical approach

In consultation with the anesthesia clinic, spinal anesthesia was applied to the patients who were deemed suitable. Unsuitable patients were operated on under general anesthesia. The medial approach was applied to all patients. The popliteal artery was explored up to the normal diameter at both the distal and proximal ends. Intravenous heparin was administered before clamping to the proximal and distal ends. The aneurysm sac was removed in all patients. Embolectomy/thrombectomy was routinely performed in all operated patients for mural thrombus or intraoperatively for thrombus or distal embolism. The vena saphena magna graft was chosen primarily. If the great saphenous vein (GSV) diameter was appropriate in the distal region in the evaluation by USG, that region was preferred to avoid infection as it is close to the genital area. The fact that the proximal part of the GSV is in deeper adipose tissue has directed us to the distal of the GSV if it was appropriate in terms of diameter compatibility. All autologous vein grafts used were GSV. While deciding on the use of autologous veins, the compatibility of the proximal and distal popliteal artery with the vessel diameter was checked. These were not used if the patient had varicose patches due to existing chronic venous disease, intimal hyperplasia due to a condition such as thrombophlebitis, or a fibrotic appearance. A ringed synthetic graft was used. End-to-end anastomosis was performed with 6-0 Prolene sutures. The procedure was terminated by placing a drain to prevent hematoma and monitor bleeding. Low-molecular-weight heparin was applied for five days after the operation. Acetylsalicylic acid + 75 mg/day clopidogrel (100 mg/day in total) was given orally. Anticoagulants (international normalized ratio: 2.0-2.5) and 100 mg/day acetylsalicylic acid were administered to patients using anticoagulants for other indications (atrial fibrillation and deep vein thrombosis).

Follow-up

After the procedure, the patients were followed up for wound infection and hematoma. Hematoma was defined as the need for aspiration or drainage. Wound infection was defined as the discharge from the incision or the growth of a sample taken from the tissue in culture. Patients were examined for routine control at the first, sixth, and 12th months after the procedure. Graft patency was inspected with Doppler USG instead of CT to avoid contrast exposure. Graft patency evaluation was based on its diameter. Patients with symptoms or occluded grafts were evaluated with CT and operated on again.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Continuous variables are expressed as the mean ± standard deviation or median (min-max), while categorical variables are expressed as numbers and percentages. A p value of <0.05 was considered statistically significant.

RESULTS

As a result of bilateral aneurysms in five patients, a total of 37 PAA operations were performed. While the mean hematocrit value of all patients was 34.7±4.8, it was 24.1±8.5 in patients with ruptured PAA due to bleeding. Concomitant diseases, preoperative laboratory values of all patients, and the drugs they used are listed in Table 1.

Ten patients were diagnosed as asymptomatic, and two of these patients had bilateral PAA. The other 25 (67.6%) limbs were symptomatic, including 14 (37.8%) with acute limb ischemia and two (5.4%) ruptured PAAs. Among these, one (2.7%) limb suffered complete motor loss and foot drop. One of our two ruptured PAA patients had a history of substance abuse, and the other was due to trauma. Both of these were true aneurysms. Popliteal artery aneurysms progressed asymptomatically in both patients until ruptured. Anterior tibial artery, posterior tibial artery, and peroneal artery embolisms were not observed in any of our patients. Of the two patients with more than 50% thrombus, one had deep vein thrombosis, and the other had neurological compression symptoms.

The dimensions of the popliteal aneurysm were 3 to 4 cm in CT angiography images of 18 (48.6%) patients. Tibial vessel runoff was in good condition in 24 (64.8%) patients. Concomitant aneurysms are listed in Table 2.

General anesthesia was performed in 20 (62.5%) patients, and spinal anesthesia was performed in 12 (37.5%) patients. Saphenous grafts were used in 21 (56.7%) patients, polytetrafluoroethylene (PTFE) in 14 (37.8%), and Dacron grafts in two (5.4%) patients. One (3.12%) patient, who underwent

emergency surgery for a ruptured popliteal artery aneurysm, died due to perioperative myocardial infarction. Two of the patients with symptomatic PAA also had angina at the time of admission to the hospital. Coronary arteriography was performed and percutaneous transluminal coronary angioplasty was applied. Numbness developed below the knee in three patients who underwent surgery for PAA, and the numbness symptoms in two patients had completely resolved at the six-month follow-up. In one patient, numbness symptoms decreased during the one-year follow-up. In one patient with ruptured PAA who underwent urgent surgery, compartment syndrome developed due to reperfusion injury, and distal perfusion was impaired. Therefore, fasciotomy was performed on the first postoperative day and closed on the seventh postoperative day. Thrombectomy was performed on a PTFE graft in one patient due to early thrombosis on the third postoperative day. The patient who underwent thrombectomy on the third day also had Behçet's disease. The median intensive care unit stay was one day (range, 0 to 3 days), and the median hospitalization period was five days (range, 3 to 11 days). Postoperative complications are listed in Table 3.

Table 2. Preoperative imaging data and other accompanying arterial aneurysms

	n	%	Median	Min-Max
All aneurysmatic limbs	37	100		
Computed tomography (diameter)				
<2 cm	0	0		
<2 cm × <3 cm	12	32.4		
<3 cm × <4 cm	18	48.6		
>4 cm	7	18.9		
Computed tomography (length), cm			4.57	3.2-6.6
Patent tibial vessels				
Insufficient (0-1 vessel)	13	35.1		
Sufficent (2-3 vessels)	24	64.8		
Associated aneurysm				
Popliteal artery (contralateral)	5	15.6		
Femoral artery	4	12.5		
Bilateral	3	9.3		
Unilateral	1	3.1		
Iliac artery				
Common iliac artery	4	12		
Internal iliac artery	1	3.1		
External iliac artery	3	9.3		
Abdominal aorta	7	21.8		
Infrarenal	6	18.7		
Suprarenal	1	3.1		
Thoracic aorta	1	3.1		
Carotis artery	1	3.1		

During the one-year follow-up period, all patients' controls were performed with Doppler USG. No stenosis was observed in the first month. One patient presented with acute arterial ischemia at five months. This patient had a PTFE graft, and a thrombectomy was urgently performed on the graft. The patient did not comply with the medical treatment, and the only outflow artery was the anterior tibial artery. Clinical improvement was achieved in all symptomatic patients. No stenosis was detected in any of the patients at the one-month follow-up. In the routine follow-up at the sixth month, stenosis of <50% was observed in two patients with PTFE grafts. In the one-year follow-up, stenosis of <50% was observed in three patients. Primary and secondary patency rates are given in Table 4.

Table 3. Postoperative complications and hospital stay

	n	%	Median	Min-Max
Cardiac	5	15.6		
Arrest	1	3.1		
Myocardial infartion	2	6.2		
Arrhythmia	2	6.2		
Pulmonary	1	3.1		
Acute kidney failure	1	3.1		
Early thrombosis	1	2.7		
Nerve damage	3	8.1		
Motor	0	0		
Sensory	3	8.1		
Deep vein thrombosis	0	0		
Fasciotomy	1	2.7		
Hematoma	2	5.4		
Wound infection	2	5.4		
Lymphatic drainage	0	0		
Wound maceration	2	5.4		
Mortality	1	3.1		
Intensive care stay (day)			1	0-3
Hospital stay (day)			5	3-11

Table 4. Patency rates

	n	%
Reintervention	2	5.4
Amputation	0	0
1 month primer patency	35	97.2
6 months primer patency	34	94.4
1 year primer patency	34	94.4
1 month seconder patency	2	100
6 months seconder patency	2	100
1 year seconder patency	2	100

DISCUSSION

A popliteal artery aneurysm is defined as a popliteal artery diameter of >2 cm or greater than 50% thrombus in the lumen.[5-14] These patients may be asymptomatic. Popliteal artery aneurysm can be diagnosed during the investigation of a pulsatile mass behind the knee or other knee joint pathologies encountered during physical examination. In addition, in the presence of aneurysms in another region, PAA may lead clinicians to investigate accompanying aneurysms.[6]

If there are possible risk factors in asymptomatic patients, they should be intervened before they become symptomatic. When PAA becomes symptomatic, it requires immediate intervention. There are significant differences between the morbidity rates of patients presenting with ruptured PAA and patients who are operated on electively.[3,10]

In addition to the surgical approach for open surgery, the application of different surgical bypass methods may also yield different results in the treatment of PAA. Medial and posterior approaches are common. In our clinical experience, it is more appropriate to completely remove the aneurysm sac to reduce compression symptoms. Furthermore, we believe that if the aneurysm sac extends distal to the superficial femoral artery, it is more accessible with the medial approach. Moreover, it is easier for the surgeon to obtain GSV conduit ipsilaterally. After the PAA is explored, graft interposition is applied without removing the aneurysm sac (inline). Another surgical technique is to perform an end-to-end anastomosis after completely removing the aneurysm sac, bypass can be performed after the aneurysm sac is ligated, and finally, the aneurysm sac can be closed on the graft after the aneurysm sac is opened and the graft is placed.[6,16,17] In another study, after the proximal and distal ends of the PAA were ligated, 65 patients who underwent bypass were followed for three years, and residual flow was observed in the aneurysm sac of five (8%) patients, while in one patient (1.5%), the aneurysm sac became enlarged and required reintervention.[18] The annual patency rate was found to be 90% in these 65 patients. The follow-up results of patients who underwent aneurysmectomy and ligation were compared, and there was no difference in primary patency at the end of the first and fifth years.[18] In our study, a complete aneurysmectomy was performed in all patients, and the one-year patency rate was 94.44%. We do not prefer surgical techniques where the aneurysm is partially removed in our clinic as the remaining sac may be filled with other lateral branches, carries a risk of rupture, and may cause nerve compression or deep vein thrombosis due to mass effect. Being aware of the anatomical neighborhood of the aneurysmatic sac is crucial in obtaining good results after complete removal. It can injure adjacent structures, such as veins and nerves. Most surgeons consider another disadvantage of our technique is that it takes relatively longer time for reperfusion compared to aneurysm exclusion and bypass, particularly in patients with acute limb ischemia. Therefore, our priority has always been the rapid implementation of the bypass. We found it appropriate to perform a bypass first and then clean the aneurysm sac in the appropriate patient. Consequently, possible nerve damage should be avoided by paying attention to the neighboring structures. No motor nerve damage was observed in our study.

In the study of Ravn et al.,[6] in which 717 PAA operations were examined, 510 patients were operated on electively, and a medial approach was applied to 621 patients. Graft interposition was applied in 163 patients, and bypass was applied to the remaining 497 patients. After graft interposition, the aneurysm sac was closed on the graft in 21 patients who were operated on with a posterior approach. No difference was observed in the one-year follow-up with other methods. At the 30-day follow-up after the surgery, there was no difference in terms of local symptoms, wound infection, or hematoma in 60 patients who underwent surgery with the posterior approach and 615 patients who underwent surgery with the medial approach. Considering the one-month patency, anastomoses with vein grafts were performed in over 90%. The patency rate of anastomoses made with prosthetic grafts was 86% ($p=0.016$). At the one-year follow-up, the patency rate of grafts made with the prosthetic vein decreased to 72%, while that of grafts made with the saphenous vein decreased to 90% ($p<0.01$). At the end of one year, 17 patients required amputation. A statistically significant correlation was found between amputation, age, and prosthetic graft in the first 30 days. In our study, the medial approach was applied to all patients, and 12 patients underwent elective surgery. The aneurysm sac was removed, and interposition was applied in all patients. Vein grafts were used in 56.75% of the patients. The one-month patency rate was 97.2%, and the one-year rate was 94.4%. Again, no amputation was observed in any of the patients during the one-year follow-up. In the study of Ravn et al.,[6] the main reason for the high number of amputations was considered to be the late

treatment of the patients. Therefore, early surgical intervention should be performed on every patient who is symptomatic. Patients presenting with acute leg ischemia should be operated on urgently.

In recent years, there has been a trend toward endovascular surgery with the developing technology. Endovascular treatment is widely used in atherosclerosis and aneurysms.[7-9] There are several studies comparing the endovascular treatment of popliteal artery aneurysm with open popliteal artery aneurysm repair.[10-13] Although the need for reintervention in the long term and the lack of any effect on compression symptoms are the negative aspects of endovascular treatment, the duration of the procedure and hospitalization are much shorter than open surgery.[9] Although no difference was observed in short-term follow-ups, open surgery was found to be superior in the long term.[12] Major amputation rates were found to be higher in endovascular treatment at the one-year follow-up.[11] Endovascular treatment can be preferred in the restricted patient group (high mortality risk and multiple comorbidities).[10] With its long-term results, open surgery is still considered the first choice in young patients and patients with compression symptoms.

The limitations of this study are its retrospective design, lack of comparison between vascular repair methods, single-center design, and the relatively shorter follow-up period of one year.

In conclusion, although a retrospective single-center study without a comparison group, this study showed the efficacy and safety of open repairs of PAAs via the medial approach. Thorough preoperative imaging evaluation and meticulous surgical technique are crucial for a better outcome after open repair.

Ethics Committee Approval: Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (Date/no: 03.01.2022/2022-1). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Conception and design, provision of study materials or patients, administrative, technical, or logistic support content, collection, analysis and/or interpretation of data, statistical expertise, drafting of the article: M.A.Y.; Conception and design, collection, analysis and/or interpretation of data, drafting of the article, critical revision of the article for important intellectual: A.A.K.; Provision of study materials or patients, administrative, technical, or logistic support content, drafting of the article, critical revision of the article for important intellectual: S.T.; Administrative, technical, or logistic support content, collection, analysis and/or interpretation of data, statistical expertise, critical revision of the article for important intellectual: Y.K.; Administrative, technical, or logistic support content, statistical expertise, statistical expertise, critical revision of the article for important intellectual: H.T.

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