

Popliteal Aneurysms, Tailored Management Options; Single-Center Experience

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Abstract

Background: This study aims to review contemporary lines of management of popliteal artery aneurysm (PAAs) illustrating the pros and cons of each treatment modality.

Methods: This is a prospective cohort study of all consecutive PAAs treated between 2015-2017. All patients' data were entered into a prospectively designed registry including all clinical, radiologic, operative and postoperative data.

Results: The study included thirty-seven PAAs in 35 patients. Management was by open repair in 48.6%, while endovascular repair in 24.3%, primary major amputation in 5.4%, and surveillance in 21.6%. PAAs were asymptomatic in 32.4% and symptomatic in 67.6% (acute ischemia in 35.1%, claudication in 32.4%, rupture in 8.1% and leg swelling and pain in 8.1%). An emergency procedure done in 29.7%, elective procedure in 51.4% and no intervention in 18.9%. Length of hospital stay in open repair was 15.1 days and in endovascular repair was 2 days. One year patency, limb salvage and mortality rates were 53.3%, 60% and 26.7%, respectively in open repair and were 75%, 100%, and .0%, respectively in endovascular repair ($p=0.526$).

Conclusions: Results of repair of asymptomatic PAAs are significantly better than those in symptomatic PAAs. In the emergency setting with severe limb ischemia and complete thrombosis of PAAs, there is significantly increased mortality, limb loss, and decreased primary patency rate. Endovascular treatment is feasible in selected patients with having adequate landing zones. A prospective randomized trial is necessary to compare the immediate and long-term outcome of endovascular repair with open repair in a large population of patients with PAAs.

Keywords: Popliteal artery aneurysm; Open repair; Endovascular repair

Introduction

The popliteal artery aneurysm (PAA) is present if the artery is enlarged 1.5 times the diameter of a normal adjacent segment of artery. In general the PAAs are rather rare, the incidence is 7.4 per 100,000 in men and only 1 per 100,000 in women. Yet they are the most common peripheral artery aneurysms, responsible for at least 70% of all peripheral aneurysms [1].

Around 14% of asymptomatic PAAs become symptomatic each year. Acute limb ischemia is present in almost one third of patients. A higher risk of complications in PAA is associated with absent distal pulses [2].

Most popliteal aneurysms are degenerative. Other rare causes of PAA include genetic defects like Behcet disease or Marfan syndrome, inflammation, infection, popliteal entrapment, and trauma to the popliteal artery [3-7].

PAAAs are considered to be “the silent killer” because of the aggressive thromboembolic events with no alarms.⁸ Those consider repairing all PAAAs, regardless of size and before limb-threatening symptoms develop realize that there would be high limb salvage and patency rates and low operative mortality for smaller, asymptomatic aneurysms. Critical limb ischemia before intervention is associated with extremely higher perioperative mortality and limb loss [1,4, 9-12].

Endovascular procedures have been applied to the management of PAA [13]. But its role is not well established yet. This study aims to assess contemporary lines of management of popliteal artery aneurysm illustrating the pros and cons of each treatment modality in the context of our population in the Middle East countries.

Materials and Methods

This is a prospective cohort study of all consecutive patients presenting to Kasr Alainy hospital, Cairo University, with PAA in the period between July 2015 and July 2017. All patients presented with PAA are included and there is no specific exclusion criteria. Patients' data were entered into a prospectively designed registry including all clinical, radiologic, operative and postoperative data. The study was approved by the ethical committee of Kasr Alainy Faculty of Medicine Cairo University with the reference ID:I-101014.

Patients were managed using the following protocol:

Conservative treatment was followed in asymptomatic patients if the diameter is less than 2cm, or the patients have high surgical and anesthetic risk. Symptomatic patient with acute ischemia undergo open surgery. Symptomatic patient with chronic ischemia undergo endovascular repair by a covered stent if PAAAs are localized to P1 and P2 with optimal proximal and distal sealing zones, or undergo open surgical repair if PAAAs are reaching P3 or the trifurcation.

Operative details of open surgical repair:

Under regional or general anesthesia using a medial approach the proximal popliteal or the distal superficial femoral artery (SFA) is exposed for proximal control followed by distal control at the lower popliteal or tibial arteries. The aneurysm is opened, thrombus evacuated, and the patent side branches of the genicular arteries over-sewn, to prevent sac enlargement from collateral blood flow into the aneurysm sac. In small thrombosed aneurysm, ligation of the aneurysm is performed followed by a bypass. When feasible, excision of the aneurysm is performed followed by an interposition graft. Take off anastomosis is the proximal popliteal or distal superficial femoral arteries. When the SFA is diseased or thrombosed, the common femoral artery is used as an inflow. A reversed saphenous vein graft from same limb is used for reconstruction or alternatively a polytetrafluoroethylene (PTFE) graft whenever no vein conduit is available.

Details of endovascular repair:

Under local anesthesia a percutaneous antegrade femoral artery approach is used. An angiogram is performed. The proximal and distal landing zones as well as the runoff vessels

are confirmed. The patient is systemically heparinized. The PAA is then crossed carefully using a hydrophilic guide wire. This is followed by placement of a self-expandable stent graft of the appropriate size. A 10 – 15% oversizing in the diameter of the stent is recommended for good fixation, with 2 cm proximal and distal landing zone. Postoperative adjuvant therapy includes dual antiplatelet agents.

For both techniques patients were followed up for the development of any new symptoms and signs, changes of the initial clinical condition, and complete exclusion of the aneurysm.

Data of the primary outcome are reported including the patency of open surgical repair or endovascular repair, amputation rates and/or any morbidity and mortality during hospital stay and during follow up.

Secondary outcome parameters included any re-interventions or conversion to another treatment modality.

The study was approved by the ethics committee of our institution, and an informed consent was obtained to all patients.

Statistical methods:

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 24. Data was summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. For comparing categorical data, Chi square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5 (**Chan, 2003**) [14]. Survival curves were plotted by the Kaplan-Meier method (**Chan, 2004**) [15]. P-values less than 0.05 were considered as statistically significant.

Results

This study included 37 PAAs in 35 consecutive patients, who fulfilled the selection criteria. Patients were predominantly males 33 (94.3%) having 35 (94.6%) out of 37 PAAs, with a mean age of 58.59 years (range 8 – 89 years). Comorbidities and risk factors are listed in (Table I).

Table I: Comorbidities and risk factors associated with PAA.

Variable	No.	(%)
Smoker	22	(59.5%)
Hypertension	22	(59.5%)
Diabetes mellitus	11	(29.7%)
Cardiac disease	9	(24.3%)
Exostoses	2	(5.4%)
Stroke	1	(2.7%)
Behcet disease	1	(2.7%)
Sheehan syndrome	1	(2.7%)
No risk	6	(16.2%)

Four (10.8%) patients had an associated abdominal aorta aneurysm (AAA), 2 (5.4%) patients had bilateral PAA and one (2.7%) patient had a renal aneurysm. PAAs were asymptomatic in 12 cases (32.4%) and symptomatic in 25 cases (67.6%); acute ischemia in 13 cases (35.1%), intermittent claudication in 12 cases (32.4%), rupture in 3 cases (8.1%) and leg swelling and

pain in 3 cases (8.1%). PAAs were on the right side in 21 (56.8%) cases and on left side in 16 (43.2%) cases.

Thirty four PAAs (91.9%) were thrombosed on presentation; either partial thrombosis in 23 cases (62.2%), or complete thrombosis in 11 cases (29.7%). There was no thrombosis in 3 cases (8.1%).

The PAAs had a mean diameter of 29.59 mm (range 16-55 mm). The mean length of PAA was 4.38 cm (range 1-15 cm). (Figure 1) shows the number of patent runoff vessels.

Management of patients was by open reconstruction in 18 (48.6%) cases, endovascular reconstruction in 9 (24.3%) cases, primary major amputation in 2 (5.4%) cases and surveillance in 8 (21.6%) cases.

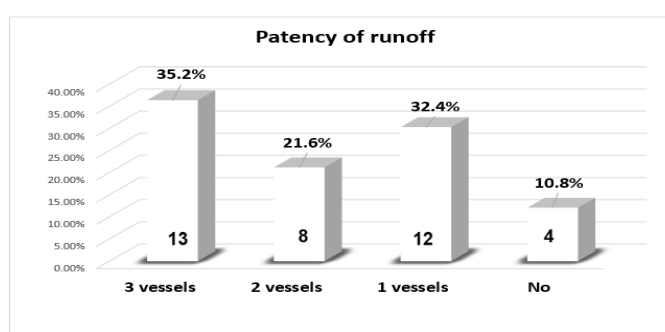


Figure 1: Demographic data showing the number of vessels with patency runoff.

Procedure details:

Eleven (29.7%) cases were performed as an emergency procedure because of acute limb threatening ischemia caused by thrombosis of the aneurysms or ruptured aneurysms. Nineteen (51.4%) cases were managed electively. Seven (18.9%) cases had no intervention, because of patient's wish in 2 cases, high surgical risk in 2 cases, and asymptomatic occlusion in one case, while 2 patients died before intervention.

One patient was initially scheduled for open surgical repair. She was 52 year old diabetic with Sheehan syndrome and presented with ruptured left PAA. During the procedure after proximal and distal control of aneurysm the patient arrested and cardiopulmonary resuscitation was done. The repair was aborted and the aneurysm was only ligated, and the patient was sent to the intensive care unit (ICU) for stabilization general condition. Fortunately, the patient's wound healed after one month, and the limb survived. The patient was followed up, added to the surveillance group and excluded from open surgery group.

Operative details of open reconstruction:

Eighteen (48.6%) patient underwent open reconstruction, 17 were males, with a mean age of 52.5 years (range 8 – 80 years). The mean PAA diameter was 31.83 mm (range 19 – 55 mm). (Table II) shows the details of patients with open surgical repair.

Eight aneurysms were treated with aneurysmectomy and graft interposition (Figure 2), while in four cases aneurysmorrhaphy was performed with graft interposition, and in 6 cases exclusion bypass was performed; proximal and distal ligation of the aneurysm with bypass graft was performed by autologous saphenous vein.

Endovascular reconstruction:

PAAAs were treated endovascular intervention in 9 (24.3%) cases; all were males with a mean age of 49 years (range 37 – 65 years). (Table II) shows the details of this group of patients. Local anesthesia was used in all procedures. The mean PAA diameter was 29.22 mm (range 18 – 45 mm). One patient presented to us by pulsating mass behind the right knee. He had a history of endovascular management of PAA 1 year before at another institute. Duplex and angiography showed type Ib endoleak and sac enlargement. A Viabahn stent graft (9×80 mm) was used to secure the endoleak. Type Ib endoleak was persistent in the completion angiography. Another Viabahn stent graft was used (10×80mm), and the final check angiography confirmed no endoleak (Figure 3).

Table II. Clinical presentation and procedure details.

Variable		No.	(%)
Open reconstruction:			
Presentation:	Asymptomatic	5	(27.8%)
	Symptomatic	13	(72.2%)
	Acute ischemia	7	(53.8%)
	Claudication	4	(30.7%)
	Compression symptoms	3	(23.1%)
	Rupture	2	(15.4%)
Number of distal Runoff vessels:	3 vessels	6	(33.3%)
	2 vessels	2	(11.1%)
	1 vessels	8	(44.5%)
	No vessel	2	(11.1%)
Approach:	Medial	18	(100%)
Site of proximal anastomosis:	Common femoral artery	1	(5.5%)
	Superficial femoral artery	8	(44.5%)
	Popliteal artery segment I	9	(50%)
Site of distal anastomosis:	Popliteal artery segment III	16	(89%)
	Anterior tibial artery	1	(5.5%)
	Posterior tibial artery	1	(5.5%)
Type of conduit:	Autogenous saphenous vein	15	(83.3%)
	Prosthetic graft (Dacron)	3	(16.7%)
Endovascular procedure:			
Presentation:	Asymptomatic	3	(33.3%)
	Symptomatic	6	(66.7%)
	Intermittent claudication	4	(44.5%)
	Acute ischemia	2	(22.2%)
Procedure:	Percutaneous	6	(66.7%)
	Cut down	3	(33.3%)
Runoff:	3 vessels	4	(44.5%)
	2 vessels	2	(22.2%)
	1 vessels	3	(33.3%)
Type and size of stent:	Viabahn	7	(77.8%)
	Fluency	1	(11.1%)
	Wallgraft	1	(11.1%)
Number of stent:	One	7	(77.8%)
	Two	2	(22.2%)

Surveillance (conservative treatment):

Eight (21.6%) cases, mean age 64 years (range 50 – 77 years), were followed up (surveillance) with no intervention because:

- 2 patients refused intervention.
- 2 patients had high anaesthetic risk.
- 2 cases presented with arterial occlusion with compensated ischemia

- 2 patients died before intervention (one died from massive myocardial infarction preoperative, and the other died from ruptured associated left renal aneurysm).

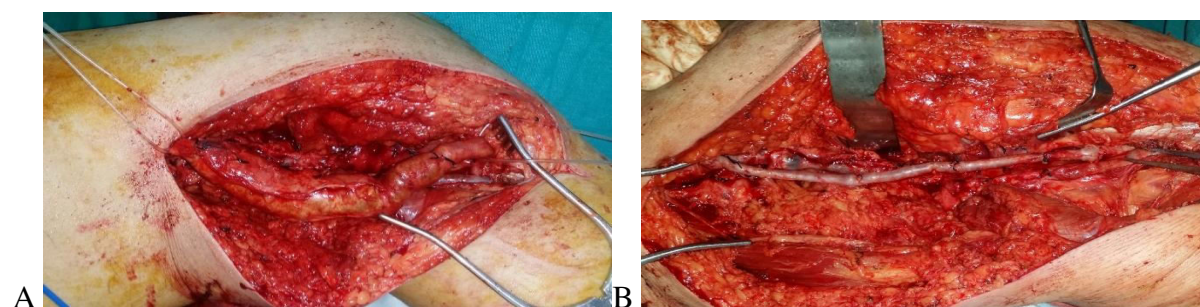


Figure 2. Excision of Lt PAA (A) and reconstruction using an autogenous saphenous graft (B).

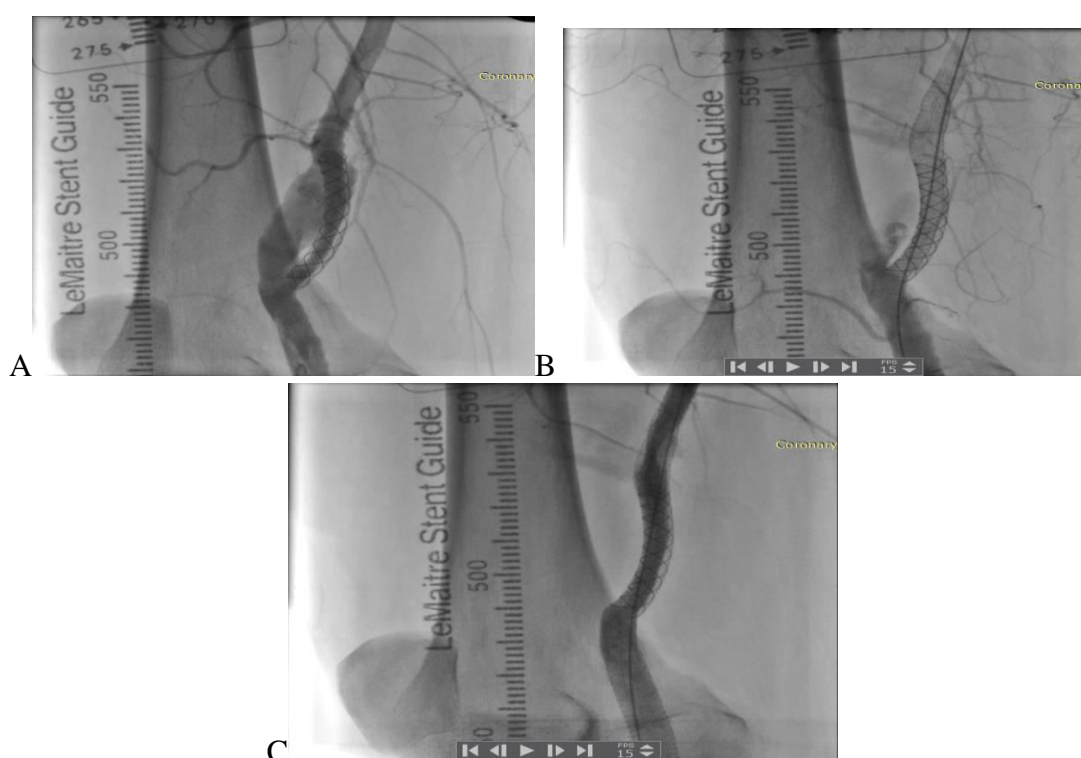


Figure 3. Endovascular treatment of right PAA previous repair endovascularly. (A) Type Ib endoleak from previous repair. (B) A Viabahn stent graft deployed with still endoleak. (C) Angiogram demonstrates exclusion of the PAA after deployed another Viabahn stent graft.

Primary major amputation:

Primary major amputation was performed in 2 (5.4%) cases; both were males, aged 77 and 89 years. Patients presented with acute limb-threatening ischemia; Rutherford Grade III in one, and Rutherford Grade IIb in the other. The second was explored and no distal run off was found so primary above knee amputation was done.

Eight patients (21.6%) experienced early (within 30 days) complications. (Table III) demonstrates these complications with their distribution among different groups.

Table III: *Complications within 30 days.*

Variable	No.	(%)
Open Group	4	(10.8%)
Endovascular Group	1	(2.7%)

<i>Surveillance Group</i>	<i>3</i>	<i>(8.1%)</i>
<i>Early mortality</i>	<i>2</i>	<i>(5.4%)</i>
<i>Major amputation</i>	<i>1</i>	<i>(2.7%)</i>
<i>Impaired wound healing</i>	<i>3</i>	<i>(8.1%)</i>
<i>Graft thrombosis</i>	<i>2</i>	<i>(5.4%)</i>
<i>Bypass thrombectomy</i>	<i>1</i>	<i>(2.7%)</i>
<i>Hematoma</i>	<i>1</i>	<i>(2.7%)</i>
<i>Lymphorrhea</i>	<i>1</i>	<i>(2.7%)</i>

The mean length of hospital stay, was 10.2 days (range 0 – 60 days) {(open group mean 15.1 days range 4 – 60 days) and (endovascular group mean 2 days range 1 – 9 days)}, and ICU stay, mean 0.5 day (range 0 – 7 days) in the open group only.

12 months follow up results:

There were a total of 6 mortalities (16.2%) (4 in the open group and 2 in the surveillance group); due to stroke (2 cases), acute renal failure (2 cases), rupture renal aneurysm (one case) and massive myocardial infarction (one case). One year primary patency rate was 61.1%, limb salvage rate was 75%, and survival rate was 83.3%. Primary patency and limb salvage during follow up 3 – 12 months in open, endovascular, and surveillance groups showing in (Table IV). ABI after 12 months was significantly higher in the endovascular group (Figure 4).

Asymptomatic limbs had better patency rates, and limb salvage than symptomatic limbs though this didn't reach statistical significance ($p=0.901$) (Figures 5 & 6).

Limbs with multiple runoff had a significantly higher limb salvage than single or no runoff ($p=0.022$) (Table V).

Elective procedure had better patency rates, limb salvage and survival than emergency procedure though this didn't reach statistical significance ($p=0.119$) (Table IV).

Discussion

PAAs are the most common peripheral artery aneurysms, responsible for at least 70% of them [1]. The main goal of treatment is to prevent limb loss due to thrombosis or distal embolization of the aneurysm [16]. It has been considered that symptomatic popliteal artery aneurysm and asymptomatic > 2 cm, with or without thrombi, should be treated [17].

Clinically 30% to 40% of aneurysms are asymptomatic in most series [7,17,18]. Galland and Magee [2] analysis shows that 25% to 80% of PAAs are asymptomatic at the time of operation. Dorigo et al. [19] reported in his 33-year experience with surgical management of 234 PAAs (41.5% asymptomatic) the mortality and limb loss rates at 13 years were 17% and 9%, respectively in asymptomatic group and 61.2% and 19%, respectively in symptomatic group.

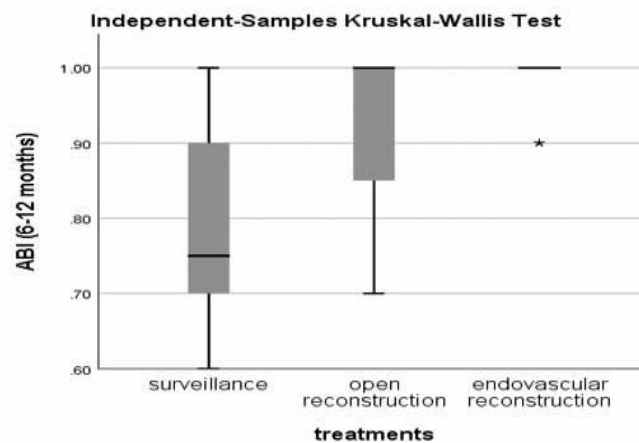


Figure 4: Comparison of ABI after 12 months in different groups.

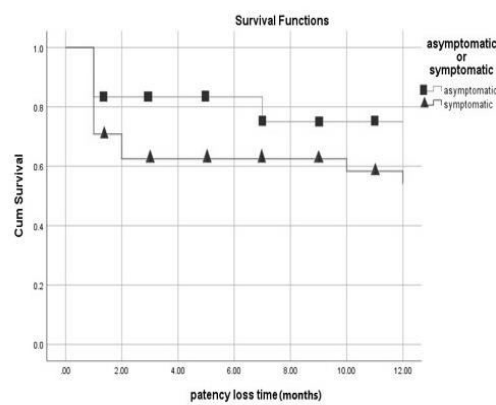


Figure 5: Kaplan-Meier curve shows primary patency in symptomatic and asymptomatic groups.

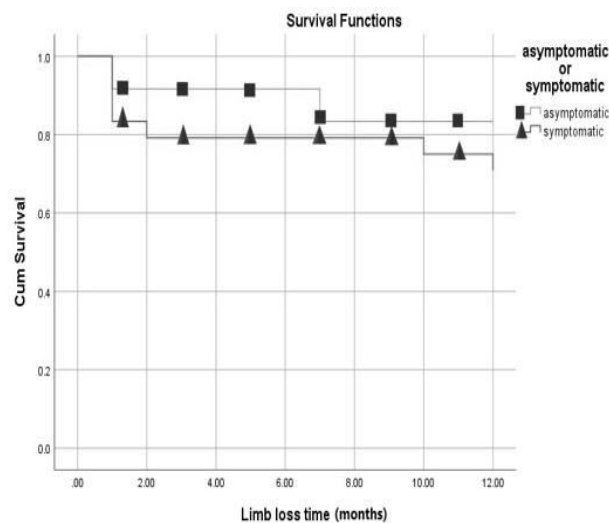


Figure 6: Kaplan-Meier curve shows limb salvage in symptomatic and asymptomatic groups.

Table IV: Patency, limb salvage and mortality rates during 12 months follow up in different groups and depend on time of the procedure.

Variable	Open		Endovascular		Surveillance		P value	Elective		Emergency		P value
	No.	(%)	No.	(%)	No.	(%)		No.	(%)	No.	(%)	
Patency	8/15	53.3 %	6/8	75%	2/5	40%	0.526	10/15	66.7 %	4/10	40%	0.225
Limb Salvage	9/15	60%	8/8	100%	3/5	60%	0.332	13/15	86.7 %	5/10	50%	0.119
Mortality	4/15	26.7 %	0/8	.0%	2/5	40%	0.526	1/15	6.7%	3/10	30%	0.119

Table V.: Patency, limb salvage and mortality rates during 12 months follow up depend on number of runoff.

Variable	No runoff		Single runoff		Multiple runoff		P value
	No.	(%)	No.	(%)	No.	(%)	
Limb Salvage	0/3	.0%	7/10	70%	13/16	81.2%	0.022

Symptomatic aneurysms, especially acute limb ischemia, poor runoff, a prosthetic graft repair, and tibial bypass have the worst outcome [20].

Table (VI) showing result of treatment of symptomatic and asymptomatic PAAs. Our study showed similar results.

Early detection and elective treatment have superior outcomes in terms of limb loss, graft patency and mortality than those who present emergently [18-21]. Table (VII) showing result of treatment of PAAs electively and emergency in multiple studies including ours showing poor outcome in emergent cases.

Cervin et al. [22] reported the use of saphenous vein was associated with better patency in all sub-groups than prosthetic graft. Table (VIII) showing results of open repair in different studies. In our study, saphenous vein was used in most cases with the exception of 3 cases using synthetic graft.

Marin et al. [23] were the first to perform endovascular repairs of popliteal artery aneurysm in 1994. Currently, endovascular treatment is a competitive treatment to the open repair, due to its advantages, of less bleeding, faster recovery, shorter hospital length of stay, offers lower risk of nerve injury, and lower morbidity and mortality [10, 24, 25]. Major limitation of endovascular treatment is the proximity to the knee joint line, complex rotation, traction, compression, and stretching forces on a short arterial segment and on the stent so that the implanted endoprosthesis is submitted to constant physical stress and increased risk of occlusion, break, and migration [17].

Table VI. Result of treatment of symptomatic and asymptomatic PAAs.

Study	Symptomatic PAAs						Asymptomatic PAAs					
	No of PAAs	1ry patency	2ry patency	Limb salvage	Mortality	complications	No of PAAs	1ry patency	2ry patency	Limb salvage	mortality	complications
Huang et al. [20]	214	91% (30 days)	NR	92% (30 days)	1.4% (30 days)	11.2% (30 days)	144	97.9% (30 days)	NR	100% (30 days)	.0% (30 days)	2% (30 days)
Dorigo et al. [19]	137	55.1% (13y)	65.6% (13y)	-96.2% (30 days) -81% (13y)	61.2% (13y)	NR	97	66.7% (13y)	71% (13y)	-100% (30 days) -91% (13y)	17% (13y)	NR
Our study	25	-72% (30 days) -52.4% (1y)	-72% (30 days) -52.4% (1y)	-84% (30 days) -66.7% (1y)	8% (30 days)	36% (30 days)	12	-91.7% (30 days) -62.5% (1y)	-91.7% (30 days) -62.5% (1y)	-100% (30 days) -75% (1y)	0% (30 days)	8.3% (30 days)

NR: not reported

Table VII. Outcome of electively and emergency treatment of PAAs in several studies.

Study	Elective PAAs repair					Emergency PAAs repair				
	No PAAs	1ry patency	2ry patency	Limb salvage	complication	No PAAs	1ry patency	2ry patency	Limb salvage	complication
Dorweiler et al. [27]	161	88.1% (5y)	NR	98.6% (5y)	16.8% (30 days)	45	88.1% (5y)	NR	91.1% (5y)	53.3% (30 days)
Huang et al. [28] open repair	93	85% (3y)	93% (3y)	NR	5% (30 days)	14	77% (3y)	84% (3y)	NR	43% (30 days)
Huang et al. [28] endovascular repair	32	75% (3y)	83% (3y)	NR	9% (30 days)	10	54% (3y)	79% (3y)	NR	50% (30 days)
Trinidad-Hernandez et al. [11]	19	-100% (30 days) -95% (1y)	100% (1y)	NR	NR	12	-83.3% (30 days) -69% (1y)	91% (1y)	NR	NR
Lichtenfels et al. [29]	34	94.1% (1y)	NR	97.1% (1y)	NR	16	66.7% (1y)	NR	56.3% (1y)	NR
Our study	19	-89.5% (30 days) -66.7% (1y)	-89.5% (30 days) -66.7% (1y)	-94.7% (30 days) -86.7% (1y)	26.3% (30 days)	11	-73% (30 days) -40% (1yr)	-73% (30 days) -40% (1yr)	-82% (30 days) -50% (1y)	36.4% (30 days)

NR: not reported

Table VIII: Outcome of open repair of PAAs.

Study	Open repair													
	No of PAAs	Saphenous vein %	Graft %	Medial approach %	inflow		Outflow		1y patency	2ry patency	Lim salvage	mortality	Graft occlusion 30 days	Reintervention 30 days
					femoral	P1	P3	tibial						
Dorigo et al. [19]	234	20.4 %	79.6 %	69.7 %	64.5 %	35.5 %	91 %	9 %	65.5 % (5y)	75.7 % (5y)	-96.2 % (30 days) -91.2 % (5y)	NR	NR	2.6 %
Dorweiler et al. [27]	206	82 %	18 %	92 %	55 %	45 %	65 %	35 %	88.1 % (5y)	96.5 % (5y)	96.9 % (5y)	2 % (30 days)	4 %	NR
Our study	18	83.3 %	16.7 %	100 %	50 %	50 %	89 %	11 %	53.3 % (1y)	53.3 % (1y)	-83.3 % (30 days) -60 % (1y)	-.0 % (30 days) -26.7 % (1y)	5.6 %	22 %

NR: not reported

With the development of low-profile flexible cover-stents for distal applications, endovascular repair has better chances for the treatment of PAAs [26].

In our study 9 (24.3%) cases were treated by endovascular approach, Viabahn stent graft (7 cases), Fluency stent graft (1case) and Wallgraft stent (1case).

Endovascular group has better patency and limb salvage in our study because of the better elective presentation and the presence of multiple runoff vessels. Thus, we cannot conduct a true comparison between the two treatment modalities.

Leake et al. [10] reported in his meta-analysis, that open repair patients were younger and more likely to have worse tibial runoff (twofold more) than endovascular repair patients, (suggest some selection biases; patients with worse runoff are undergoing open repair). Sousa et al. [18] reported in his literature review, that emergent cases were managed more frequently by open repair (0-43%) compared with endovascular repair (0-38.7%).

In our study, stent graft thrombosis occurred in 2 (22.2%) out of 9 cases treated by endovascular intervention at follow up for one year (Fluency and Wallgraft stents were used). It's worth mentioning that loss of patency after endovascular treatment did not lead to limb loss. However, the occurrence of two asymptomatic stent graft occlusions among the 9 cases (22.2%) was considered less than satisfactory result in view of the optimal preintervention condition (mild presentation and excellent distal run off) of this group of patients. In the other seven cases Viabahn stent graft was used with no complications. We had no endoleaks in our patients. Only one patient who had his primary endovascular treatment in another center presented with type 1b endoleak and was treated by 2 Viabahn stent grafts.

Limbs with multiple runoff had a significantly higher limb salvage and patency rate than single or no runoff [7, 20].

CONCLUSIONS

Results of repair of asymptomatic PAAs are good and are significantly better than those with repair on symptomatic PAAs. Elective open repair should be performed in patients with a low surgical risk and with a long life expectancy. In the emergency setting with severe limb ischemia and complete thrombosis of PAAs, there is significantly increased mortality, limb loss, and decreased primary patency rate.

Endovascular treatment is feasible in selected patients with have adequate landing zones. Early presentation and surveillance are crucial for better outcome which need to be thoroughly addressed to our population.

A prospective randomized trial is necessary to compare the immediate and long-term outcome of endovascular repair with open repair in a large population of patients with PAAs.

Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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