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Long-term results of open repair of popliteal artery aneurysm

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HIGHLIGHTS

- 30 day Primary patency rate: 100% asymptomatic legs; 92% for symptomatic legs.
- Better quality of life quality for asymptomatic legs in the follow-up.
- Better ankle-brachial index for asymptomatic legs on control examination.

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ABSTRACT

Introduction: Popliteal artery aneurysms (PAA) are rare. Different surgical techniques for open surgical repair are possible. This study presents a single centre experience using open surgical repair with a medial approach (MA) and outlines differences between symptomatic (SLS) and asymptomatic (ALS) legs.

Methods: Data collection was performed retrospectively. The investigation period was from 1 January 1996 to 1 January 2013. Patients presented in the Outpatient Department and received a questionnaire concerning their quality of life. Data are presented as mean ± standard deviation. Mann–Whitney test and Cochran–Armitage test for trend was used for data analysis. Kaplan–Meier method was used to calculate limb salvage rates. $p < 0.05$ was considered statistically significant.

Results: We analyzed 16 ALS and 26 SLS with an average age of 63.5 ± 10 years. Preoperative ankle-brachial index (ABI) was 1.0 ± 0.2 for ALS (on control examination: 1.12 ± 0.24) and 0.08 ± 0.18 for SLS (on control examination 0.94 ± 0.14) ($p < 0.05$). Limb salvage rate was 100% for ALS and 86.7% for SLS (overall 93.3%). Primary patency rate for SLS was 85%, for ALS rate of 100%, respectively (overall 92.5%). ALS reached an average of 13.1 ± 2.7 points (SLS 11.4 ± 2.8) on a numeric point scale.

Conclusion: Open surgery is therapy and prevention of acute ischaemia all in one, especially for asymptomatic patients and delivers good long-term results. Endovascular therapies offer an alternative but long-term results are pending. Open surgery should still be considered as a gold standard therapy.

1. Introduction

Popliteal artery aneurysm (PAA) constitutes a rare disease in the general population; however, it is the most common peripheral aneurysm [1]. Its prevalence is about 1%, and patients are almost exclusively men of an age between 65 and 80 years [2]. Although rare and mostly asymptomatic, up to 20% of affected patients present acute symptoms [3]. The occurrence of symptoms may indicate severe complications. Thus, peripheral embolism, local aneurysm thrombosis and free aneurysm rupture are consequent pathologies. Resulting critical limb ischaemia has a poor prognosis with an amputation rate of about 15% [4,5].

Open operative and endovascular therapy are common therapeutic options for patients with PAA today. Interventional approaches are frequently used for aneurysms in different locations [6,7]. The first report of successful interventional therapy for PAA was published in 1994 and since new stents have been developed, as the flexible knee joint segment of the popliteal artery has special mechanical demands [8]. The method is more frequently used,

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indicated by an increasing number of reports within the last years [9–12]. However, there is no consensus on a standardized approach so far. To date, most hospitals consider localized expansion over 20 mm in diameter or 150% of the normal vessel diameter with proximal and distal healthy vessels as indicators for operative or endovascular treatment [13,14].

Concerning open surgical repair, different operation techniques and approaches are described in the literature. Two alternative approaches, which are both equally popular, are the medial approach (MA) with the patient in the supine position and the posterior approach (PA) with the patient in the prone position [15,16]. Fig. 1 illustrates the operation situs using an MA and a sliced PAA after excision. Surgical solutions include a bypass with anastomoses in an end-to-side fashion or an interponate with an end-to-end anastomosis. Alternatively, an incision of the aneurysm sac, consecutive creation of an interponate with an end-to-end anastomosis and secondary coverage by re-closure of the aneurysm sac may be performed [17]. Results after surgical repair are interesting, especially in comparison to endovascular therapies, and should help with offering the best treatment for patients.

This study analyses data of patients with a PAA who underwent open surgical repair. It outlines long-term results and patients' life quality after open surgical repair of asymptomatic and symptomatic PAA. Moreover, it compares the results with data after endovascular treatment drawn from the literature.

2. Methods

2.1. Data collection

Retrospective data analysis was approved by the review board of the University of Düsseldorf (4856). All patients gave their informed consent prior to the analysis. Data were analyzed retrospectively. A review of these data was conducted including 30 patients at an average age of 63.5 ± 10 years, who were treated for PAAs from 1 January 1996 to 1 January 2013 at the Department of Vascular and Endovascular Surgery at the University Hospital Düsseldorf. Twelve patients underwent open surgery for both legs due to co-existing contralateral PAA. Operations were performed by senior surgeons and an MA with saphenous vein graft interposition was conducted. Thus, aneurysms were completely removed. Alternatively, a saphenous vein bypass was performed and the PAA was ligated. During the operation the aneurysm was assessed and allocated to one of the following subgroups: thrombosed, embolized, plain aneurysmatic and concomitant inflammatoric reaction. Patients' characteristics and data of the in-hospital stay were analyzed from archived medical records (Table 1).

Table 1
Characteristics of the patient cohort.

	Frequency ALS $n = 11$ (%)	Frequency SLS $n = 19$ (%)
Gender		
Male	10 (91)	18 (95)
Female	1 (9)	1 (5)
Risk factors		
Hypertension	8 (73)	13 (68)
Dyslipoproteinemia	4 (36)	12 (63)
Smoking	5 (45)	10 (52)
Adipositas (BMI > 30 kg/m^2)	2 (18)	8 (42)
Additional aneurysms		
Abdominal aorta	5 (45)	9 (47)
Contralateral popliteal artery	9 (82)	11 (58)
Iliac artery	1 (9)	0 (0)
Visceral arteries	1 (9)	0 (0)

2.2. Control examination and assessment of the quality of life

The rest of the data were collected prospectively. Patients were invited to present in our outpatients' department for control examination. Fifteen patients presented in the outpatients department and seven patients were examined by their general practitioner, and the results were transmitted to our department. Two patients did not present and six patients have died in the meantime. Here, results from older control examinations were used for analysis. For control examinations anamnesis and physical examination were performed, followed by calculation of the ankle-brachial-index (ABI) and a duplex sonography (Toshiba Xario). Thus, the streaming profile and the maximum diameter were assessed.

Together with the invitation, patients received a questionnaire to consider the psychosocial outcome. We developed a questionnaire with six questions concerning current physical condition, pain, self-confidence and viability. The questions could be answered as follows: 0 = very unsatisfied 1 = not satisfied, 2 = satisfied, 3 = very satisfied. Points were added up and results were interpreted as follows: 0–3 points: very bad quality of life, 4–8 points: bad quality of life, 9–13 points: good quality of life, 14–18 points: very good quality of life. Altogether we received 21 questionnaires for examination, meaning a return rate of 70%.

2.3. Statistical analysis

Graph Pad Prism® Version 5.01 was used to plot graphs and perform analyses. Percentages are presented for categorical

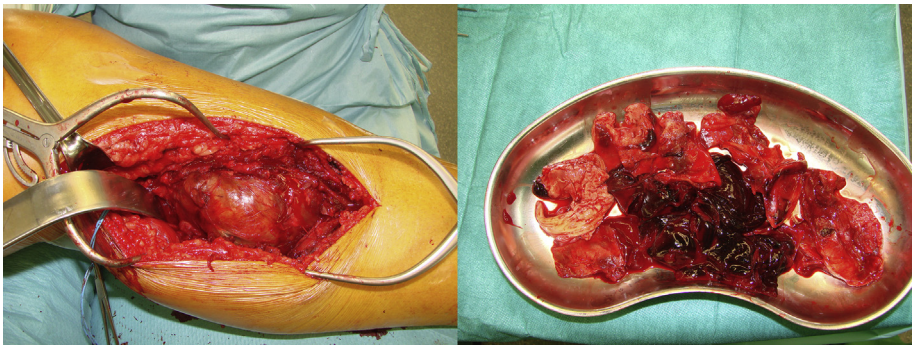

Fig. 1. Operation situs using a medial approach and a sliced PAA after excision. Shown is the situs during the operation using an interponate and a medial approach (left). After total excision the aneurysm was sliced (right).

variables; continuous variables are presented as mean and standard deviation. A Mann–Whitney test was performed to compare categorical variables and the Cochran–Armitage test for trend was used for analyzing rating scales. The Kaplan–Meier method and a log-rank test were used to compare limb salvage rates. $p < 0.05$ was considered statistically significant.

3. Results

We included 30 patients, meaning 42 legs in total. Of these, 16 (38.1%) legs presented with an accidentally diagnosed PAA and were asymptomatic. Twenty-six (61.9%) legs presented with symptoms caused by limb ischaemia due to the PAA. Thus, 14 (33.3%) legs described symptoms of intermittent claudication, classified as Fontaine stage II, and ten (23.8%) legs had rest pain, classified as Fontaine stage III. Two legs (4.8%) suffered from unspecific symptoms such as swelling in the popliteal fossa or a feeling of tension in the affected leg.

After the operation, surgeons allocated the PAA to one of the following subgroups: thrombosed, embolized, plain aneurysmatic and concomitant inflammatoric reaction. Thus, 16 legs (38.3%) showed a plain aneurysmatic dilation, 14 legs (33.3%) a thrombosed aneurysm, 11 legs (26.2%) presented with distal embolization and on one leg (2.4%) a concomitant inflammatoric reaction was described. Fig. 2 illustrates the distribution of pre-operative symptoms and clinical aspects of PAAs of all 42 legs.

To evaluate postoperative results, the ABI was calculated from the ratio of ankle and brachial systolic blood pressure two to four days after operative repair. Results for symptomatic (SLS) and asymptomatic legs (ALS) were considered separately to conclude on operative success dependent on pre-operative clinical presentation. ALS showed an average ABI of 1.0 ± 0.2. 62.5% of ALS had a normal ABI between 0.9 and 1.2. SLS had an average ABI of 0.98 ± 0.18, respectively. In this group 50% of all legs had a normal ABI, meaning 71% of legs with symptoms of intermittent claudication and 30% of legs with rest pain. Control examinations in the outpatient department were performed at 71.1 ± 58.5 months for ALS (76.2 ± 60 months for SLS). Thus, ALS showed an ABI of 1.12 ± 0.24 (SLS 0.94 ± 0.17). At that time, the difference of ABI on both study groups was statistically significant (Mann–Whitney *U* test $p = 0.016$). Fig. 3 shows the results comparing the ABI of ALS and SLS legs two to four days postoperatively and on control examination. Using duplex sonography, 100% of the interponate showed regular flows; however, two interponates showed an ectasia and one interponate a slight stenosis.

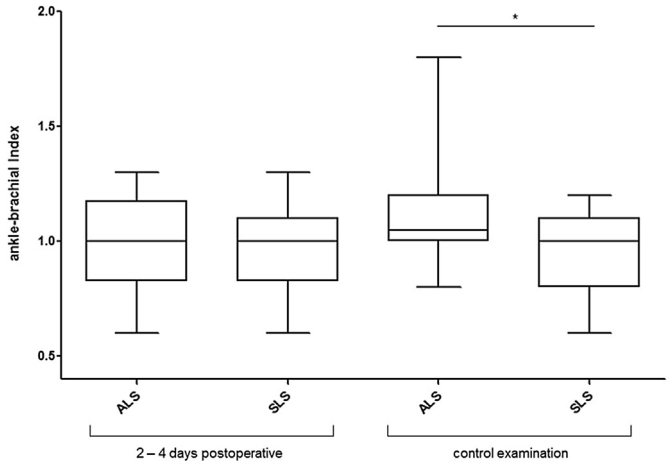

Fig. 3. Ankle-brachial index for asymptomatic and symptomatic patients. Results of the ankle-brachial index two to four days postoperative (left) and on control examination (right) are shown. Data are presented for asymptomatic (ALS) and symptomatic (SLS) legs separately (*$p < 0.05$ Mann–Whitney *U* test).

Concerning the postoperative course 12 (75%) ALS and 21 (80.3%) SLS cases showed no complications (Fisher's exact test $p = 0.71$). Table 2 lists the total number and frequencies of postoperative complications. Among SLS, two cases (7.7%) showed an occlusion of the interponate (one and nine days postoperatively) and had to undergo immediate revision surgery with the creation of a popliteo-popliteal bypass. In both cases a return occlusion, resulting in acute lower leg ischaemia, could be observed and lower extremity amputation had to be performed.

Postoperative 30-day limb salvage rate was 100% for ALS and 86.7% for SLS, meaning an overall limb salvage rate of 93.3%. The Kaplan–Meier curve illustrates these results (Fig. 4). The difference was not statistically significant ($p = 0.31$). On control examination (mean 67 months for ALS; 84 months for SLS), the patency rate for ALS was 100%. SLS showed a primary patency rate of 85% and a secondary patency rate of 100%. Thus, the mean follow-up period was 38.7 ± 29.2 months and primary patency rate was 92.5%; the secondary patency rate was 100%.

ALS rated their quality of life predominantly as 'good' and reached an average of 13.1 ± 2.7 points (SLS 11.4 ± 2.8). Interestingly, one symptomatic patient rated his quality of life as bad (eight points), whereas 29% of ALS rated their quality of life as 'very good' (21% SLS). Differences were not statistically significant

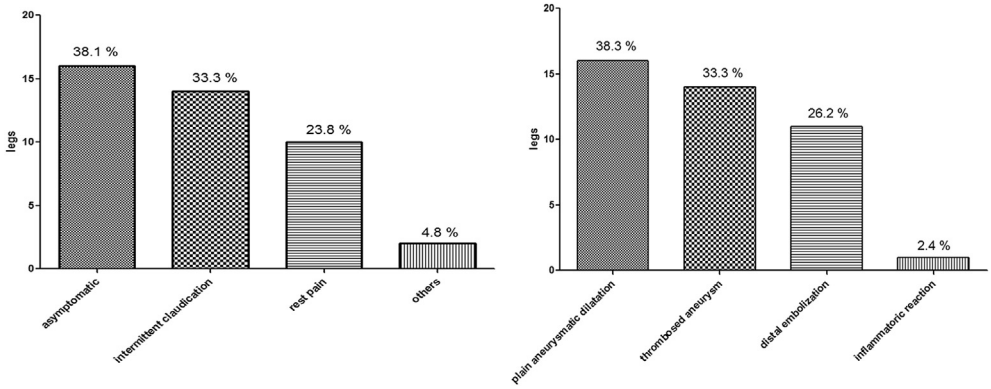

Fig. 2. Distribution of preoperative symptoms and clinical aspects of PAA. Patients were assessed on pre-operative clinical symptoms and clinical aspect of the PAA. The percentage distribution and total number of legs for each subgroup is shown.

Table 2
Shown is the total number and percentages of postoperative complications for ALS and SLS.

Complication	Symptomatic $n = 26$ (%)	Asymptomatic $n = 16$ (%)
No complication	21 (80)	12 (75)
Wound healing disorder	1 (4)	3 (19)
Postoperative haemorrhage	2 (8)	1 (6)
Interponate occlusion/lower leg amputation	2 (8)	–

(Cochran–Armitage test for trend $p = 0.18$ on a numeric scale and $p = 0.56$ on a categorical scale) (Fig. 5).

4. Discussion

The study shows that open surgical repair with an MA represents a safe treatment strategy for PAAs. An overall limb salvage rate of 93.3% after open surgical repair is in accordance with results of Davis et al. and Mahmood et al., who reported similar results [18,19].

To achieve ideal patient treatment surgeons have to consider essential issues. An important issue is whether an MA or PA would be beneficial. Evaluating the Swedish National Registry for Vascular Surgery, both approaches provide comparable results concerning primary patency rates [20]. Other authors have described comparable patency rates and long-term results. However, they have stated that the PA, even if the field of view may be limited, may be preferred. They have reported a risk of long-term aneurysm growth using an MA of up to 22% [15,21]. Other authors would not commit themselves to a statement on a preferred approach [17,22].

Although not evaluated in this study, the prevention of aneurysm growth after operative repair should be one major task in the overall concept. Re-perfusion of the aneurysm and renewed aneurysm growth may result in the occurrence of symptoms like swelling and claudication in up to 88% of all cases [20,23]. It should be emphasized that using venous interposition, with an end-to-end anastomosis and total excision of the aneurysm, this long-term complication can be prevented. However, this surgical procedure is not always feasible due to aneurysm size and localization; the authors of this study believe that its use may be beneficial and should therefore be the first surgical option.

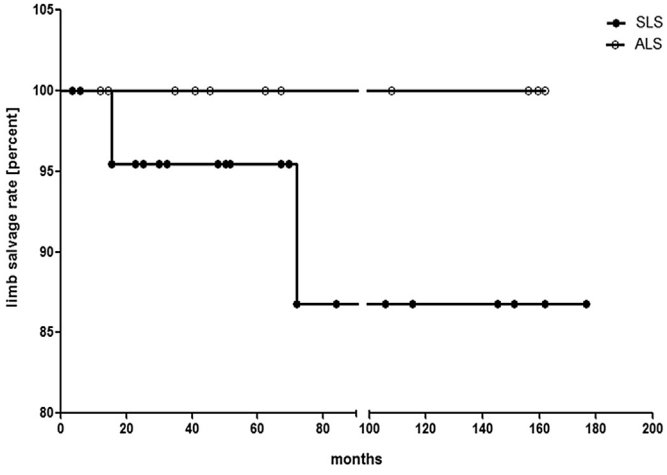

Fig. 4. Kaplan–Meier curve for limb salvage rate after open surgical repair. Limb salvage rates for asymptomatic (ALS) (100%) and symptomatic (SLS) (86.7%) legs after open surgical repair (log-rank test $p = 0.31$) are shown.

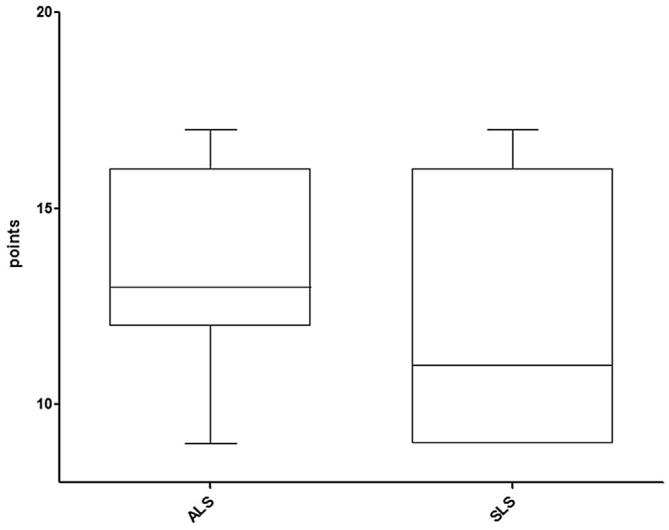

Fig. 5. Questionnaire on quality of life after open surgical repair of PAA. The questionnaire consisted of six questions concerning the quality of life (0–3 points each). Results were added up, meaning a maximum of 18 points. Results are presented separately for asymptomatic and symptomatic (Cochran–Armitage test for trend $p = 0.18$).

Besides open surgical solutions, endovascular therapies have gained interest within the last two decades. Mollenhoff et al. recently reported a limb salvage rate of 99.2% in a cumulative follow up of 36.9 months using GORE® VIABAHN® Endoprosthesis (W. L. Gore and Assoc Inc., Flagstaff, AZ, USA). He outlined a one year primary patency rate of 85.6% (secondary patency rate was 93.4%) [24]. Although endovascular techniques mean shorter operation time and reduced length of in-hospital stay, there are relevant complications that might occur. Technical successful implantation can be achieved in almost 100% of all cases and this depends in particular on the run-off [25]; however graft thrombosis is described in up to 7%, endoleaks in up to 6%, stent migration in up to 5.2% and stent fracture in up to 16.7% [12,24,26]. In summary, patency rates seem to be, by tendency, higher, and re-intervention rates are lower using open surgical repair. Short-term lethality may be comparable [27,28]. As long-term results are still pending, the authors of this study believe that an open surgical approach provides a safe method with satisfying long-term results, and should be considered as the first therapeutic option. The cost-efficiency aspect sees no advantage as a result of endovascular therapy [29]. Thus, interventional approaches should for now be designated to multimorbid patients with high operative risk.

A scientific dispute on obligatory indicators for interventions on asymptomatic patients has been going for years. Asymptomatic patients have a risk of around 8–100% of becoming symptomatic within one year [30,31]. The results of this study show that the majority of asymptomatic patients rate their quality of life as 'good' and ABI on control examination proves reproducible success. In view of this fact, the authors of this study consider an open surgical approach for patients with localized expansion over 20 mm in diameter or 150% of the normal vessel diameter as reasonable indicators for open surgical repair in asymptomatic patients [13,14]. For symptomatic patients, immediate treatment is necessary. For this group of patients, preoperative thrombolysis remains a single-case decision as randomized studies are limited [32,33].

PAA is a rare disease; however, open surgical repair delivers reproducible therapeutic success. For asymptomatic patients, open surgery is therapy and prevention of acute ischaemia all in one. The MA with venous interposition or popliteo-popliteal saphenous vein

bypass with total aneurysm excision delivers good long-term results. Asymptomatic patients rated their quality of life generally better than symptomatic patients, congruent with a better long-term ABI. Endovascular therapies became an alternative, but there is a considerable complication and re-interventions rate and cost-effectiveness considerations see no advantage for endovascular therapies so far. As safety for asymptomatic and symptomatic patients using open surgical repair is high, and the outcome is convincing, it remains the gold standard treatment up to now.

Ethical approval

The present analysis was approved by the review board of the University of Düsseldorf (study number 4856). All patients gave their informed consent prior to the analysis.

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Author contribution

Markus U. Wagenhäuser contributed substantially to the conception and design of the manuscript. He drafted the article and revised it critically. He contributed to the final approval of the published version. Katharina B. Herma collected the data and analysed them. She contributed substantially to the statistical analysis. Tolga A. Sagban helped to write the article and contributed to its design. He participated in essential data interpretation. Philip Dueppers helped to improve the quality of the manuscript by revising it critically, and contributed designing the figures and tables. Hubert Schelzigand Mansur Duran helped to draft the manuscript. They participated in conceiving and designing the manuscript. All authors approved the final version of the manuscript.

Conflicts of interest

The author(s) declare that they have no competing interests.

Guarantor

All authors approved the final version and take over responsibility for the work.

Consent

All patients gave their informed consent prior to the analysis. Data had not to be altered.

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