Treatment of popliteal vein aneurysms

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CME Activity

Purpose or Statement of Need The purpose of this journal-based CME activity is to enhance the vascular specialist's ability to diagnose and care for patients with the entire spectrum of circulatory disease through a comprehensive review of contemporary vascular surgical and endovascular literature.

Learning Objectives

- List the common complications of popliteal venous aneurysms
- Discuss the treatment of options for popliteal venous aneurysms

Target Audience This activity is designed for vascular surgeons and individuals in related specialties.

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ABSTRACT

Objective: Popliteal vein aneurysms are associated with high risk for deep venous thrombosis (DVT) and pulmonary embolism. The goal of this study was to report treatment strategies for popliteal vein aneurysms and their outcome after long-term follow-up.

Methods: All patients between June 1993 and June 2018 with diagnosed popliteal vein aneurysm were enrolled in this study and analyzed retrospectively. They received regular surveillance alone or treatment. Patients were offered aneurysm resection or lifelong anticoagulation if they had aneurysm size of twice normal vein diameter. All patients received clinical examination and duplex ultrasound examination 3 to 6 months after operation or primary diagnosis and annually thereafter.

Results: A total of 39 patients (aneurysm size, mean 23.3 mm) were treated by either operation or anticoagulation (31/39 [79%]) or surveillance alone (8/39 [21%]). Patients with an aneurysm >20 mm in diameter had a significantly higher incidence of turbulent flow on duplex ultrasound examination with higher risk for development of DVT ($P = .029$). Of the 31 patients with a therapeutic approach, 29 (94%) preferred resection, whereas 2 (6%) patients were treated with lifelong anticoagulation and compression. Mean follow-up was 57.9 ± 12.5 months.

Conclusions: According to these results, it seems that patients with large popliteal vein aneurysms experience DVT more frequently. Therefore, popliteal vein aneurysms >20 mm should be considered for surgical treatment or lifelong anticoagulation, depending on the patient's preference. (J Vasc Surg: Venous and Lym Dis 2019;7:535-42.)

Keywords: Popliteal vein aneurysm; Deep venous thrombosis; Therapeutic anticoagulation; Aneurysm resection

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Venous aneurysms are rare. They are usually published as case reports or case series.[1-5] In 1992, Schild et al[6] showed that 311 venous aneurysms had been described since 1939. In 2016, a total of 1199 venous aneurysms had been reported.[7] Portal vein aneurysms were the most frequent type of venous aneurysms (n = 247), followed by popliteal vein (n = 223) and jugular vein aneurysms (n = 143).[7]

In 1993, Aldridge and Comerota[8] published the first review of aneurysms of the popliteal vein, encompassing 24 such aneurysms reported in the world literature. Another study showed an incidence of popliteal vein aneurysms of 0.2%.[4] In 2006, a study described 105 popliteal vein aneurysms after a systematic search of the literature.[9] All the popliteal vein aneurysms in these studies were treated surgically, diagnosed after deep venous thrombosis (DVT), pulmonary embolism (PE), or leg swelling.[10-13]

Venous aneurysms can be defined as a persistent isolated dilation of twice the normal vein diameter.[14] They are attributed to truncal vascular malformations. As for arterial aneurysms, a distinction is made for venous aneurysms between fusiform and saccular aneurysms. A distinction is also made between primary and secondary aneurysms. The etiology of primary aneurysms remains wholly unclear; congenital and inflammatory causes are discussed. Among the possible causes of secondary aneurysms, venous hypertension (eg, due to arteriovenous fistula formation), portal vein hypertension,[15] compression, and direct trauma[4,7] are discussed.

ARTICLE HIGHLIGHTS

- **Type of study:** Single-center retrospective cohort study
- **Key Findings:** Of 39 patients with popliteal vein aneurysm, 29 had a size of >20 mm. These had significantly more turbulence on ultrasound and more deep venous thrombosis than smaller aneurysms; 29 underwent resection with good outcome.
- **Take Home Message:** Patients with popliteal vein aneurysm diameter >20 mm should be considered for surgical resection or lifelong anticoagulation.

The goal of this study was to report treatment strategies for patients with popliteal vein aneurysms and their outcome after long-term follow-up.

METHODS

Study design. This study is a retrospective analysis based on a registry of patients with popliteal vein aneurysm treated with operative resection or lifelong anticoagulation or regular surveillance alone between June 1993 and June 2018. Patients' data were collected concurrently and documented in a database (M1; CompuGroup Medical, Koblenz, Germany) incorporating multiple variables, such as patients' demographics, comorbidities, neurologic symptoms, and variables related to aneurysm anatomy or treatment, after

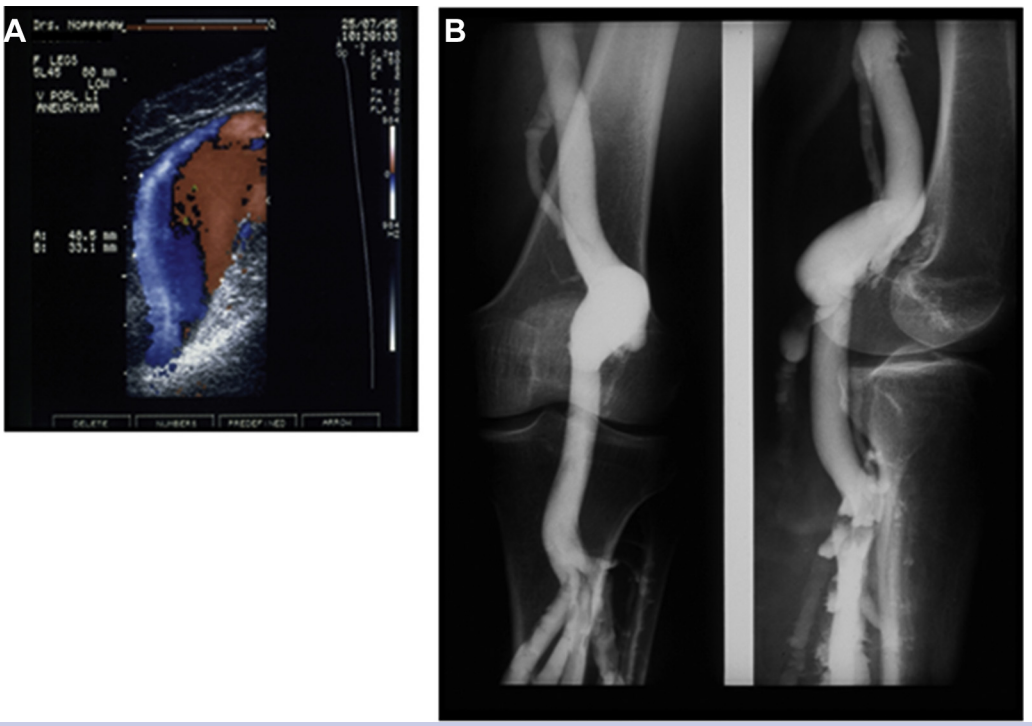

Fig 1. Images of patients with popliteal vein aneurysm. **A,** Color-coded duplex ultrasound image showing turbulent flow in the popliteal vein. **B,** Venography of a patient with popliteal vein aneurysm.

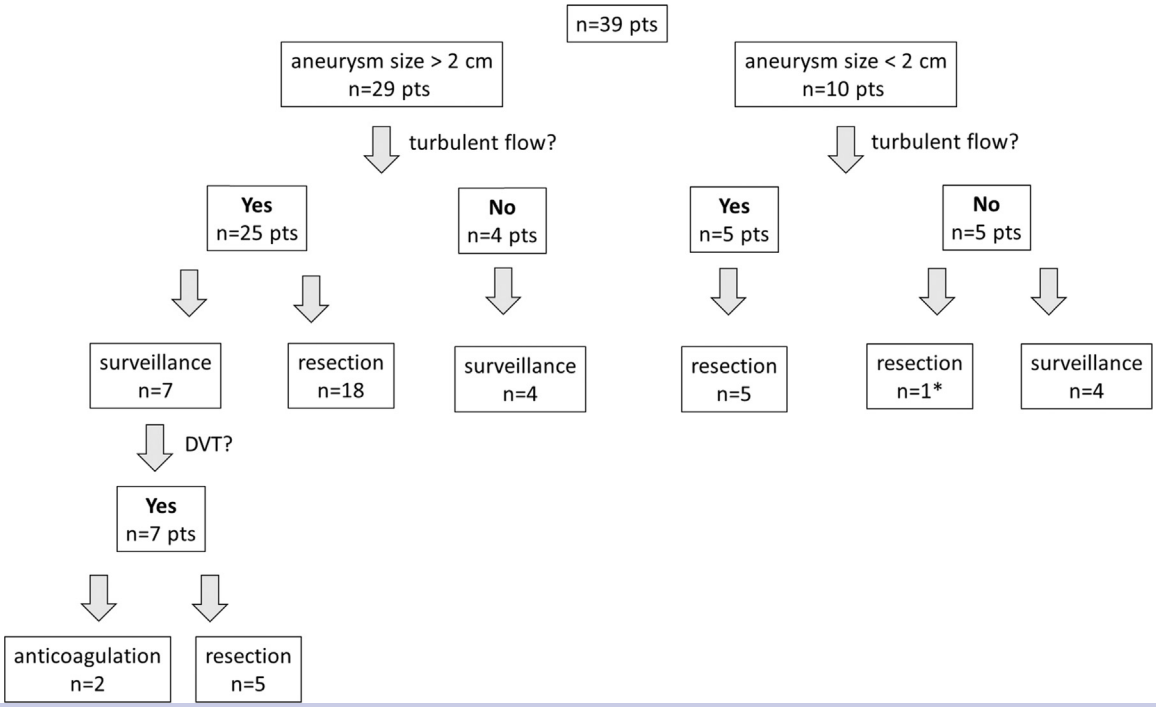

Fig 2. Therapeutic approach to patients with popliteal vein aneurysm. During routine duplex ultrasound examination in the upright position, aneurysm size was measured. For patients with turbulent flow (pendulum flow), a therapeutic approach was chosen. Seven patients with aneurysm size >2 cm and turbulent flow with no treatment of the popliteal vein aneurysm were referred to our institution after deep venous thrombosis (*DVT*). Surgery was recommended in these patients. Two refused operative treatment and received anticoagulation. One patient with small aneurysm and no turbulent flow decided to have surgery because of his fear of thromboembolism.

approval by the local ethics committee (reference No. 2018-162). The main variables did not change over the entire recruitment period, and the same diagnostic protocol was used. Strengthening the Reporting of Observational Studies in Epidemiology guidelines were used to report this study.[16] Workup consisted of clinical examination and duplex ultrasound examination. Surgery in all cases was performed by two vascular surgeons, duplex ultrasound by the team members. Duplex ultrasound scan was initially done for varicose vein diagnostics and exclusion of DVT. Popliteal vein aneurysms were incidental findings. All scans were performed in the upright position because venous enlargement is reduced in the horizontal position (Fig 1).

Indications for therapeutic approach. A therapeutic approach was recommended when the aneurysm showed turbulent flow by duplex ultrasound (Fig 2)

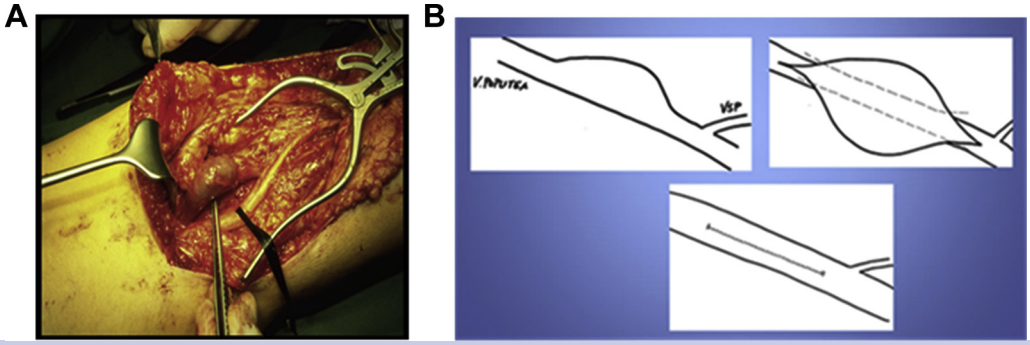

Fig 3. Aneurysm of the popliteal vein, intraoperative finding and schematic representation of the surgical procedure. **A,** The popliteal vein is exposed. **B,** After surgical presentation of the popliteal vein, longitudinal incision is performed, followed by tangential resection of the aneurysm and direct suturing. *VSP,* Small saphenous vein.

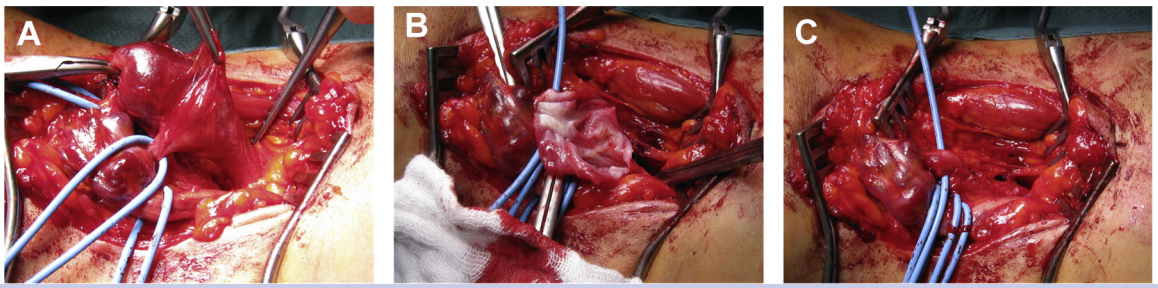

Fig 4. Operative resection of the popliteal vein aneurysm. Example of a fusiform popliteal vein aneurysm, diameter 22 mm. **A,** The exposed popliteal vein is marked by tweezers. **B,** After longitudinal venotomy, the aneurysmal changes of the venous wall are visible. **C,** Resection of the aneurysmal venous wall and direct suturing of the vein.

and the diameter was >20 mm, corresponding to the doubled diameter of a normal popliteal vein, measured in the upright position.[13] We defined turbulent flow as a pendulum in the flow wave.

Operative treatment. Procedures performed were resection of the aneurysm and direct suturing of the popliteal vein with ligation of the small saphenous vein, combination of resection and direct suturing with aneurysmorrhaphy, patchplasty, resection, and end-to-end anastomosis (Fig 3). The most often used procedure was resection of the aneurysm with direct suturing of the popliteal vein. After clamping of the popliteal vein, the diseased and aneurysmal part of the wall could be easily identified and resected (Fig 4). All procedures were performed from the posterior approach, in prone position (Figs 3 and 4).

The postoperative regimen consisted initially of therapeutic anticoagulation for 3 months and compression stockings of 20 to 30 mm Hg up to the thigh, also for 3 months. Postoperative wound infection was graded according to the Centers for Disease Control and Prevention (CDC) guidelines.[17] Patients presented for control 1 week and 2 weeks after surgery. In case of noncompliance with wearing of compression stockings, patients received instructions on the importance of compression and help for dressing them. After 3 and 6 months, patients were checked by ultrasound.

End points of the study. The primary end point was prevention of DVT as assessed in follow-up visits. Secondary end points were the rate of early reinterventions and popliteal vein diameter increase during follow-up.

Calculations and statistical analysis. Data were collected prospectively in an institutional database, and then deidentified data were transferred to a Microsoft Excel database (Microsoft, Redmond, Wash). Data were analyzed using SPSS version 26.0 (IBM, Armonk, NY). Descriptive data for numeric variables are given as mean ± standard error or median values. Possible correlations between variables were calculated using a χ^2 test with Pearson or Fisher exact test to indicate statistical significance for categorical variables. A P value <.05 was considered to be statistically significant.

RESULTS

Characteristics of the patients. From June 1993 to June 2018, there were 39 patients diagnosed with popliteal vein aneurysms. This represents 0.06% of all patients (n = 49,439) referred to the institution in Nuremberg during that period for clarification of a venous disorder. Thirty-three of the patients were female and six were male; their ages ranged from 18 to 86 years (average, 57.3 years; Table I). Of the 39 patients, 24 (62%) patients with aneurysm size twice normal vein diameter were assessed for primary treatment. Patients were offered

Table I. Patients' characteristics, risk factors, and aneurysm-related parameters

Characteristics	(N = 39)
Age, years	57.4 ± 2.0
Male/female	6/33
Varicose veins	21 (54)
Heart disease	6 (15)
Hypertension	17 (44)
Aneurysm diameter, mm	23.3 ± 1.2
DVT	7 (18)
Turbulent flow on duplex ultrasound	30 (77)
Fusiform/saccular	29/10

DVT, Deep venous thrombosis.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard error.

Table II. Anatomic localization of the aneurysm

Visualization	Popliteal	Popliteal and tibial	Fibular
Duplex ultrasound	39	0	2
Surgery	23	4	2

Table III. Risk factors for deep venous thrombosis (*DVT*) development in patients with surveillance alone (n = 15)

	(n = 15)	DVT (n = 7[a])	No DVT (n = 8)	*P*
Age, years, mean	61.4	70.7	54.9	.014
Male/female	3/12	1/6	2/6	.6
Aneurysm diameter, mm, mean ± SE	21.3 ± 1.0	23.7 ± 1.5	19.2 ± 0.81	.008
Aneurysm diameter >20 mm	11	7	4	.029
Turbulent flow	7	7	0	.001
Fusiform/saccular	13/2	5/2	8/0	.1

SE, Standard error.
[a]All seven patients with DVT received a therapeutic approach later on; two (29%) chose lifelong anticoagulation, and five (71%) received aneurysm resection.

surgical resection or lifelong anticoagulation, depending on their choice. After duplex ultrasound examination, 37 patients had isolated popliteal vein aneurysm and 2 had an aneurysm of the fibular vein (Table II). After surgical exposure of the region, we had to rectify our evaluation; in four cases, the aneurysm involved the tibial veins.

Risk factors for DVT development in patients with primary surveillance. In the primary surveillance group, 7 of 15 (47%) patients had experienced DVT before they were referred to our institution, no patient after primary therapy ($P = .001$). Five of these seven patients (71%) with DVT in the medical history received surgical resection later on; two (29%) rejected the operation and received therapeutic anticoagulation and compression stockings. Risk factors for DVT development in patients with primary surveillance were age ($P = .014$), aneurysm diameter ($P = .008$), aneurysm size >20 mm ($P = .029$), and turbulent flow in the aneurysm sac on duplex ultrasound ($P = .001$; Table III). The incidence of turbulent flow in the popliteal vein aneurysm formation strongly correlated with the aneurysm diameter. Larger aneurysms were associated with turbulent flow as analyzed by color-coded ultrasound ($P = .01$; Fig 5).

Surgical treatment. Of the 31 patients with a therapeutic approach, 29 (94%) chose surgical resection of the popliteal vein aneurysm (Table IV). Of them, 23 had an isolated popliteal vein aneurysm, 4 a popliteal vein aneurysm with involvement of the junction with tibial veins, and 2 an isolated aneurysm of the fibular vein.

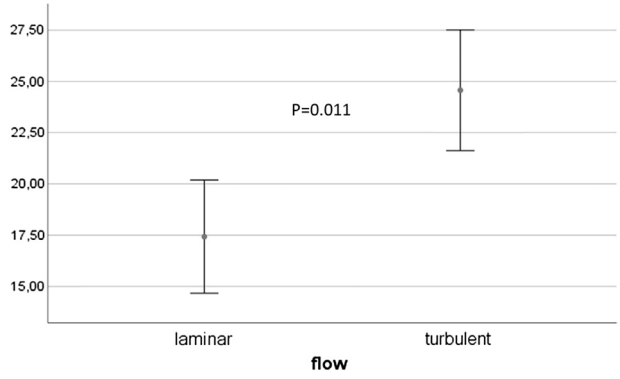

Fig 5. Relationship between popliteal vein aneurysm diameter and flow characteristics. Higher aneurysm diameter may lead to turbulent flow ($P = .011$).

Postoperatively, 2 of 29 (7%) patients developed wound infections, 1 CDC grade 1 and 1 CDC grade 2. Two patients experienced secondary bleeding in the popliteal fossa due to postoperative anticoagulation with unfractionated heparin. In these two patients, the hematoma was evacuated surgically; one of these patients suffered permanent paresis of the muscles that lift the foot as a result of compression by the hematoma (Fig 6). In all 29 surgical patients, histology revealed fibrosis of the aneurysmal wall segments, partial calcification, decrement of the intima, and increase in collagenous fibers in the media in some specimens.

Follow-up. During follow-up (mean, 57.9 ± 12.5 months; range, 1-262 months), no occlusion or DVT was observed after surgical resection, and no other complications were seen after 6 months or 1 year after the operation. After 2 years, one patient presented with a thrombosed small saphenous vein. After a mean of 10.5 years, two patients presented with venous incompetence in the reconstructed area of the popliteal vein, with a maximum vein diameter of 18 mm. During the primary reconstruction, we did not find a valve in the aneurysmal popliteal vein. One female patient developed a recurrent popliteal vein aneurysm (diameter, 17 mm) and underwent redo surgery because of severe turbulent flow (Fig 6). In this case, the original operation was resection of the popliteal vein aneurysm and closure of the vein with a patchplasty. In

Table IV. Operative procedures in patients with aneurysms of the popliteal vein

Operative procedure	No.[a]
Tangential resection, direct suture	23
Tangential resection, patchplasty	1
Tangential resection and aneurysmorrhaphy	3
Resection of popliteal vein and end-to-end anastomosis	2

[a]There were 24 patients with primary surgery and 5 patients after deep venous thrombosis (DVT).

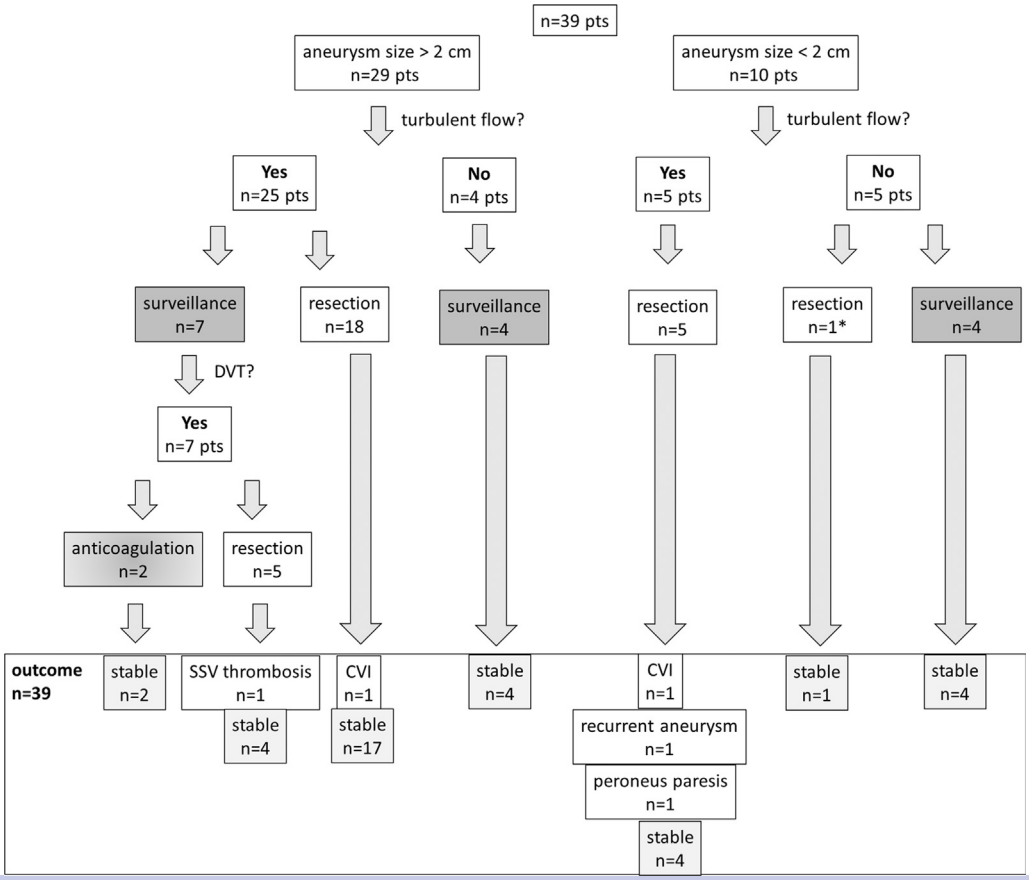

Fig 6. Therapeutic approach to and outcome of patients with popliteal vein aneurysm. Patients in the surveillance group had stable aneurysm size during follow-up. Two patients in the surgical group experienced postoperative bleeding with hematoma evacuation; one of them had permanent peroneus paresis. One patient with aneurysm resection and patchplasty developed recurrent popliteal vein aneurysm with indication for reintervention. Two patients developed chronic venous insufficiency (*CVI*) of the popliteal vein in the resected area. One patient developed thrombosis of the small saphenous vein (*SSV*) 2 years after reconstruction. No deep venous thrombosis (*DVT*) or vein occlusion occurred after resection. *This patient was afraid of getting a DVT and wanted to have resection of the popliteal vein aneurysm.

18 patients, varicose vein surgery was carried out during follow-up. No DVT occurred during follow-up in the reconstructed area.

In the surveillance group (n = 8 patients), no thrombosis occurred in the aneurysmal area of the popliteal vein during follow-up. None of the aneurysms exhibited an increase in size or new blood flow irregularities with turbulent flow. Two of these patients were treated surgically for varicose veins during follow-up.

DISCUSSION

Venous aneurysms are rare vascular disorders. Popliteal vein aneurysms are the second common type of venous aneurysm.[7,18]

The most common complications of popliteal vein aneurysms described in the literature are DVT and PE. Bergqvist et al[9] reported four cases ending in death. So far, we have not found systematic studies of large patient series or data from epidemiologic studies regarding popliteal vein aneurysms.[18-20] Schild et al[6] estimated the risk for development of a PE in a venous aneurysm at 6%.[6] In our study, small aneurysms with laminar flow showed low risk for DVT. Another work group described a similar subgroup of patients with popliteal vein aneurysms who were only observed and in whom no thrombosis occurred in the aneurysm during a mean follow-up time of 38 months.[10]

The tool of choice for diagnosis of popliteal vein aneurysms is color-coded duplex ultrasound. It has the advantage that it can depict not only morphology but also blood flow disturbances, such as turbulent and retrograde flow in the aneurysmal segments. These zones harbor the risk of thrombus formation according to the Virchow triad of the causes of DVT. The flow information provided by color-coded duplex ultrasound allows a risk assessment of possible thrombus formation in popliteal vein aneurysms.[18]

The pathogenesis of the popliteal vein aneurysm remains unclear. Interestingly, 54% of the patients with popliteal vein aneurysm in this study presented with a

concomitant varicosis of the great saphenous and small saphenous vein. Venous hypertension leads through activation of vascular endothelial growth factor receptor to angiogenesis, cell proliferation, and migration of smooth muscle cells into the intima and media, with thickening of the intima layer.[21,22] Chronic inflammation due to high intravenous pressure might promote the migration of the vascular smooth muscle cells and the development of venous aneurysm.[23] Estrogen leads to increased nitric oxide production and therefore an increase of angiogenesis. This might be an explanation for the higher prevalence of venous aneurysm in women. As mentioned, other causes are discussed, such as congenital and inflammatory causes. Compression and direct trauma are other possible causes of venous aneurysms.[4,7,15]

In this study, patients in the primary surveillance group had significantly higher risk for DVT. Risk factors for DVT development were age, aneurysm diameter >20 mm, and turbulent flow in the aneurysm sac on duplex ultrasound. Turbulent flow on duplex ultrasound was associated with large aneurysm diameter and might be a phenomenon for early detection of popliteal vein expansion and prediction of increased risk of DVT leading to risk for thromboembolic events. Therefore, patients with a large popliteal vein aneurysm or with previous DVT received a therapeutic approach, consisting on lifelong anticoagulation or surgical resection, depending on the patient's preference. Interestingly, the two patients who chose lifelong anticoagulation, aware of the bleeding risk, were treated during the last 5 years. There might be a change in patients' preference because of easy handling and less risk of bleeding of the new oral anticoagulation drugs in comparison to vitamin K antagonists. After surgical treatment, 1 of 29 (3%) patients developed recurrent popliteal vein aneurysm after patchplasty with indication for surgical reintervention after 10.5 years of follow-up. Hence, recurrent aneurysm was observed after patchplasty and in none after aneurysm resection (in one patient [100%]); patchplasty might not be the favorable option for aneurysm resection. Recurrences have been described 2 years and 4 years after surgical reconstruction in other publications.[1,11,12,24]

Therapeutic anticoagulation is indicated perioperatively and after discharge. The literature has no data regarding how long anticoagulation should be given. In this study, patients received 3 months of therapeutic anticoagulation under the assumption that this allowed sufficient time for endothelium to overgrow the suture line in the vein.[2,18,25]

The recommendation for surveillance alone was small aneurysm diameter with no turbulent flow. All patients received compression stockings. Patients with surgical resection stopped the compression therapy after 3 months. During long-term follow-up, the conservative group showed no relevant aneurysm growth or DVT.

In this study, DVT in patients with popliteal vein aneurysm was associated with age and aneurysm diameter >20 mm with turbulent flow. Surgery was recommended to those patients because of the estimated high risk of thrombus formation. The majority of the patients decided for surgical reconstruction. Only two refused surgery; they received therapeutic anticoagulation. In patients with small popliteal vein aneurysm without alterations in blood flow, surveillance alone seems to be sufficient, and anticoagulation was not indicated.

This study has some limitations. It is a single-center retrospective analysis of a rare entity. On the other hand, it is the largest series of popliteal vein aneurysms published so far. Most cases of popliteal vein aneurysms are case reports with complications. Therefore, with the evidence presently available, it is difficult to give definitive recommendations on how to handle these cases. This analysis, however, could contribute to the body of knowledge on the treatment of popliteal vein aneurysms.

CONCLUSIONS

According to the results of this single-center experience, patients with popliteal vein aneurysm diameter >20 mm, in most cases associated with a turbulent flow phenomenon, might benefit from surgical resection or lifelong anticoagulation to prevent DVT or PE.

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AUTHOR CONTRIBUTIONS

Conception and design: TN, RK, BC
Analysis and interpretation: TN, RK, BC
Data collection: TN, KP, WS, JN, BC
Writing the article: TN, RK, BC
Critical revision of the article: TN, RK, KP, WS, JN, BC
Final approval of the article: TN, RK, KP, WS, JN, BC
Statistical analysis: RK, BC
Obtained funding: Not applicable
Overall responsibility: TN

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