

# Risk of new aneurysms after surgery for popliteal artery aneurysm

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**Background:** The risk of developing a new aneurysm after surgery for popliteal artery aneurysm (PAA) is not well known. The aim was to study this risk in a cohort of patients.

**Methods:** A total of 571 patients who had primary operation for PAA (717 legs) between 1987 and 2002 were identified from the Swedish Vascular Registry (Swedvasc). Of these, 190 patients were re-examined by ultrasonography after a median of 7 (range 2.9–18.7) years.

**Results:** The number of patients with at least one aneurysm in addition to the PAA was 108 (56.8 per cent) at the index operation and 131 (68.0 per cent) at re-examination. The overall number of aneurysms increased by 41.8 per cent, from 244 to 346. Among the 82 patients who had an isolated PAA at the index operation, 23 developed a new aneurysm; these patients tended to be older ( $P = 0.004$ ). Bilateral PAA at the index operation was associated with a later development of abdominal aortic aneurysm ( $P = 0.004$ ). Age ( $P = 0.004$ ) and hypertension ( $P = 0.012$ ) at the time of the index operation were associated with multianeurysm disease at any time. Six (4.3 per cent) of 138 legs treated by venous bypass grafts had developed a graft aneurysm by the time of re-examination. No normal arterial segment developed an aneurysm that required surgery within 3 years.

**Conclusion:** The development of new aneurysms was common in patients with a PAA; lifelong surveillance may be warranted.

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## Introduction

Follow-up after treatment of a popliteal artery aneurysm (PAA) focuses on surveillance of the reconstruction, normally ultrasonography during the first postoperative year. Although routines differ between centres, patients have often completed follow-up by 1 year. Whether continued surveillance is warranted remains controversial<sup>1</sup>.

PAA are often bilateral and associated with abdominal aortic aneurysm (AAA)<sup>1–5</sup>. The prevalence of aneurysms in other anatomical positions, at different time points, among patients who have surgery for unilateral or bilateral PAA is not well known. The only previous study<sup>1</sup> reported on 50 patients identified between 1958 and 1985 and followed for a mean of 5 years; ultrasonographic imaging was available only in the later years. This information is crucial in order to determine whether a surveillance programme is worthwhile and should include investigation of the operated PAA,

because dilatation and aneurysm formation in venous grafts and even of the excluded aneurysm have been reported<sup>6,7</sup>.

The aim of this study was to investigate the long-term risk of developing new aneurysms in the contralateral leg, in other anatomical positions and in the venous graft of patients who had surgery for PAA. The risk factors for developing new aneurysms during follow-up were also investigated.

## Methods

A total of 571 patients who had a primary operation for PAA on 717 legs between 1987 and 2002 were identified from the Swedish Vascular Registry (Swedvasc). The study design, including extensive validation of registry data, has been described in detail previously<sup>2,6,8</sup>. Core surgery is registered with great validity in the Swedvasc<sup>9–11</sup> and this is also relevant for PAA procedures.

The number of bilateral and extrapopliteal aneurysms at the time of the primary PAA procedure (index operation) was based on information from patients' records at the local hospital. It was not always possible to distinguish whether an aneurysm was known previously, or if it was diagnosed in connection with the index operation. The characterization of any aneurysmal dilatation at the time of the index operation, based on data from case records, was clear for all contralateral popliteal arteries and abdominal aortas, although not for all femoral and iliac arteries. Most patients had been investigated by ultrasonography.

In Sweden every citizen has a unique personal identity code, which is used as the identification code in the Swedvasc. In January 2005 data were cross-checked against the national population registry, resulting in accurate survival data: 337 patients were alive at that time, and were asked to participate in a telephone interview and a re-examination, of whom 240 agreed.

The patients were asked about smoking habit, medication, family history of aneurysms, history of amputation and of aneurysm repair in the contralateral popliteal artery or at other anatomical locations, and any symptoms from the operated leg.

A total of 192 patients (242 legs) participated in the re-examination. Two patients (three legs) had a clinical examination only and were excluded from this study. Most patients who declined to participate in the interview or re-examination were either elderly or infirm. Several patients died between the telephone interview and the re-examination, and others decided to participate in the telephone interview only.

The re-examination was carried out at one of 38 local hospitals, during 2005–2006. The principal investigator, together with the same experienced ultrasound technologist from the vascular laboratory at Uppsala University Hospital, examined 163 patients by visiting the local hospital. Another 27 patients were examined by a local vascular surgeon and ultrasound technologist (25) or by computed tomography (two). The bypass was examined for flow, aneurysm formation and stenosis. The previously operated PAA was evaluated for size and blood flow in the aneurysm sac, and the patients were screened for aneurysms in other arterial segments: infrarenal aorta, common iliac arteries, common femoral arteries and contralateral popliteal artery. The ultrasonographic examination took approximately 20 min. Any previously unknown aneurysm found at re-examination was reported to the local surgeon for treatment or included in the local aneurysm surveillance programme. If the patient had a history of aneurysm repair at any location, the date of the operation was noted.

**Table 1** Definitions of aneurysm in the different arterial segments

	Diameter of vascular segment (mm)
Infrarenal aorta	≥ 30
Common iliac artery	≥ 20 or 50% larger than the contralateral side
Common femoral artery	≥ 15
Popliteal artery	≥ 15

The definition of aneurysms used at re-examination is given in *Table 1*. Hypertension was defined as self-reported, medically treated, hypertension, and smoking as ever smoked at the time of the index operation. Multianeurysm disease was defined as any additional aneurysm (aortic, iliac, femoral or contralateral popliteal aneurysm) at any time (before or after index operation until re-examination). A new AAA or contralateral PAA was defined as one treated before re-examination or detected at re-examination, but not operated on or known about at the index operation.

The study was approved by all nine Regional Ethics Committees in Sweden. According to the administrative rules of the Swedvasc, each patient is asked for informed consent before registration. Each patient gave written informed consent before re-examination.

### Statistical analysis

Independent samples *t* test was used for comparison of normally distributed data and Fisher's exact test for comparison of two proportions. To estimate the odds ratio (OR) for factors associated with multianeurysm disease (after adjustment for sex, age, hypertension, smoking, first-degree relative with aneurysm and duration of follow-up), the variables were entered into a logistic regression model. Separate models were analysed for new AAA (or no AAA) and new contralateral PAA (or no contralateral PAA) as the dependent variables, where only subjects at risk were included. Thus, those with an AAA or PAA who had surgery before, or known about at, the index operation were excluded from the respective analysis. Bilateral PAA was included in the model when AAA was analysed, and AAA when contralateral PAA was analysed.

### Results

Seven (3.7 per cent) of the 190 patients who participated in the telephone interview and the re-examination were women. The median (range) age of the group at index operation was 64 (18–84) years for men and 56 (22–79) years for women; age at re-examination was 71 (29–91) and 63 (30–85) years respectively. The median interval from index operation to re-examination was 7 (range 2.9–18.7) years. Information on hypertension was obtained for 188

**Table 2** Prevalence of multiple aneurysms at three time points

	Treated before index operation	All aneurysms at index operation	All aneurysms at re-examination
Total no. of patients	190	190	190
Total no. of aneurysms	76	244	346
No. of additional aneurysms			
None	159 (83.7)	82 (43.2)	59 (31.1)
Extra aneurysms	31 (16.3)	108 (56.8)	131 (68.9)
One	9 (4.7)	47 (24.7)	41 (21.6)
Two	6 (3.2)	21 (11.1)	26 (13.7)
Three	12 (6.3)	19 (10.0)	25 (13.2)
Four	2 (1.1)	13 (6.8)	24 (12.6)
Five	1 (0.5)	2 (1.1)	8 (4.2)
Six	1 (0.5)	6 (3.2)	7 (3.7)
No. of affected regions			
Only index PAA	159 (83.7)	82 (43.2)	59 (31.1)
Extra regions	31 (16.3)	108 (56.8)	131 (68.9)
One	13 (6.8)	54 (28.4)	43 (22.6)
Two	14 (7.4)	28 (14.7)	40 (21.1)
Three	3 (1.6)	18 (9.5)	28 (14.7)
Four	1 (0.5)	8 (4.2)	20 (10.5)

Values in parentheses are percentages. Four possible regions were evaluated: aortic, iliac, femoral and contralateral popliteal regions. PAA, popliteal artery aneurysm.

subjects, on smoking for 190, and on family history of aneurysm disease for 189 patients.

The total cohort of 571 patients had a median (range) age of 71 (18–94) years at the time of the index operation, 63 (18–84) years in the group re-examined, 70 (38–92) years among non-attenders and 76 (31–84) years among those who had died by the time of invitation for re-examination.

### New aneurysms after popliteal artery aneurysm repair

The distribution of extrapopliteal aneurysms and PAA in the contralateral leg at index operation and re-examination is shown in *Table 2*. The number of patients with multiple aneurysms (at least one aneurysm in addition to the index PAA) at the index operation was 108 (56.9 per cent), which increased to 131 (68.9 per cent) after a median follow-up of 7 years. Between the index operation and re-examination the total number of aneurysms increased from 244 to 346 (by 41.8 per cent); the 102 new aneurysms developed in 74 patients.

The location of the new aneurysms that developed during the interval between the index operation and re-examination is shown in *Table 3*. Of 117 non-index aneurysms that were evaluated on re-examination, 61 (52.1 per cent) required operation. Of 72 new aneurysms, not previously detected but identified during re-examination, 32 (44 per cent) needed repair.

Of 82 patients who had an isolated PAA at the index operation, 23 developed new aneurysms during follow-up.

**Table 3** Distribution and size of aneurysms at re-examination

	Diameter (mm)	Total no.	Diagnosed at re-examination
Aorta	30–39	16	13
	40–49	10	8
	≥ 50	6	3
Popliteal*	15–19	8†	6
	≥ 20	29	15
Iliac‡	< 25	16	10
	25–29	8	7
	≥ 30	3	2
Femoral	< 20	6	2
	≥ 20	15	6

\*Contralateral popliteal artery. †Six of these small popliteal artery aneurysms had mural thrombus, requiring surgery. ‡Three patients had bilateral iliac artery aneurysms.

They tended to be older at the index operation (mean age 64.0 *versus* 59.7 years;  $P = 0.004$ ). None of the 23 patients developed or had surgery for a new aneurysm within 3 years. Nine patients, however, had the non-index aneurysm detected during the fourth or fifth year of follow-up. Six of these patients had an aneurysm detected at re-examination; five met the criteria for surgery, three of whom had an AAA. Aneurysms in the other three patients were detected and operated on before re-examination (two PAA and one femoral artery aneurysm).

Of 108 patients with known non-index aneurysms at the primary operation, eight were re-examined within 3 years.

Two of these had no new aneurysm, five had been treated surgically for an aneurysm known at the index operation (four PAA and one AAA) and one patient had an operation for a femoral artery aneurysm not detected at the primary operation.

### Factors associated with the development of AAA after popliteal artery aneurysm surgery

Thirty-four AAA developed in 139 patients (24.5 per cent) with no AAA or history of AAA repair at the index operation. In a univariable analysis bilateral PAA at the index operation was significantly associated with the development of AAA ( $P = 0.004$ ), whereas sex, age, hypertension, smoking, family history of aneurysm and duration of follow-up were not. Bilateral PAA retained the association with development of AAA in a logistic regression model after adjustment for all other factors (OR 2.96, 95 per cent confidence interval 1.26 to 6.98;  $P = 0.013$ ).

### Factors associated with the development of popliteal artery aneurysm in the contralateral leg

Of 110 patients with no PAA or history of PAA repair in the contralateral leg at index operation, 28 (25.5 per cent) developed a contralateral PAA. No significant associations were observed in univariable analysis, whereas both age (OR 1.1 per year;  $P = 0.036$ ) and duration of follow-up (OR 1.2 per year;  $P = 0.030$ ) were associated with the development of PAA in a logistic regression model after adjustment for all other factors.

### Factors associated with multianeurysm disease

Of all 190 patients, 131 had a history of or developed additional aneurysm(s) at any site during follow-up. Univariable analysis revealed that age ( $P = 0.004$ ) and hypertension ( $P = 0.012$ ) at index operation were significantly associated with multianeurysm disease, whereas sex, smoking, family history of aneurysm and follow-up time were not. Age (OR 1.1 per year;  $P = 0.003$ ) and hypertension (OR 2.1;  $P = 0.041$ ) retained an association with multianeurysm disease in a logistic regression model after adjustment for all other factors. In addition, duration of follow-up was significantly associated with multianeurysm disease (OR 1.1 per year;  $P = 0.036$ ).

### Aneurysm formation in venous grafts

A vein graft was used in 140 (58.6 per cent) of 239 PAA repairs among 190 patients. Six of the 239 legs were

amputated before re-examination, two of which had a vein graft. Thus, 138 legs with a vein graft PAA repair were re-examined. In six (4.3 per cent) there was segmental aneurysm formation of the vein graft. The time between index operation and re-examination in these patients ranged from 5 to 15 years. Five of the legs had a reoperation through a medial approach and one through a posterior approach. Five reconstructions were with reversed vein and one involved an *in situ* bypass.

### Discussion

Most published reports on PAA have focused on surgical management and results; few studies reported long-term outcome<sup>1,6,12-14</sup>. Patients with PAA are known to have a high prevalence of extrapopliteal aneurysms<sup>1,2,12-15</sup>, but the risk of developing new aneurysms during follow-up after PAA repair is almost unknown. In this study, an additional 102 aneurysms developed in 74 patients, demonstrating the value of a surveillance programme. Early detection is fundamental to allow treatment before limb- or life-threatening complications occur.

Of 571 patients treated surgically for PAA and registered in Swedvasc, 190 (33.3 per cent) were re-examined and included in the study. Some 233 patients were no longer alive at the time of invitation, and so the true attendance rate was 56.2 per cent. In cohort studies it is essential to analyse and report subjects lost to follow-up. No information was available on the prevalence of aneurysms or the cause of death among non-attenders. The present study is not a true cohort study, although data obtained at index operation were registered prospectively. Non-attenders were older than attendees. As age was a risk factor for multianeurysm disease it is likely that non-attenders would have had an even higher prevalence of additional aneurysms, had they been examined.

Age, hypertension and duration of follow-up were independently associated with multianeurysm disease, in accordance with previous reports<sup>1,15</sup>. Only 59 of 190 subjects did not develop any additional aneurysms. Whether isolated aneurysms and multiple aneurysms represent two separate cohorts is not clear. Subjects with isolated aneurysms were younger and had shorter follow-up, indicating that they may just have been studied at different stages of disease.

Bilateral PAA at the index operation was independently associated with the later development of AAA, in accordance with the report of Dawson and colleagues<sup>15</sup>. The presence of an AAA at the index operation for PAA was, however, not associated with the later development of contralateral PAA, suggesting that bilateral PAA is a

stronger marker for generalized aneurysm disease than the combination of a PAA and an AAA.

Although all patients with hypertension were receiving medical treatment, no information was available on the blood pressure, nor on the compliance with anti-hypertensive treatment. The possible preventive effect of antihypertensive therapy is therefore difficult to evaluate.

No patient developed a new aneurysm requiring surgery within 3 years of the index operation, but later during the fourth and fifth years several such aneurysms were detected. Based on this observation a practical suggestion would be to reinvestigate for new aneurysms every 3 years. Surveillance of known aneurysms was not the topic for this study, but has been investigated previously<sup>5,12,16–19</sup>.

Dawson and colleagues<sup>1,15</sup> suggested that patients older than 65 years, or with hypertension, are at high risk of developing a new aneurysm and should be in a lifelong surveillance programme after PAA repair. This recommendation can certainly be supported by the findings of the present study.

The development of new aneurysms is common among patients operated on for PAA. A complete examination of the aortoiliac and femoropopliteal arteries is warranted at the time of surgery. Consideration should be given that all patients, regardless of age or other risk factors, be kept under lifelong surveillance to detect and treat new aneurysms. This study suggests that previously normal arterial segments should be re-examined every 3 years.

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