

Nationwide study of the outcome of popliteal artery aneurysms treated surgically

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Background: The aim was to study the epidemiology and outcomes of popliteal artery aneurysm (PA) treated surgically.

Methods: Among 110 000 procedures registered prospectively in the Swedish Vascular Registry (Swedvasc), there were 717 primary operations for PA among 571 patients. Patient records were reviewed and data validated against other registries.

Results: The median age of the patients was 71 years; 5.8 per cent were women. Among 264 legs treated urgently, 235 had acute ischemia and 24 had rupture. Of patients with unilateral PA, 28.1 per cent had an aortic aneurysm, 8.4 per cent an iliac aneurysm and 9.4 per cent a femoral aneurysm. Extra-popliteal aneurysms were more common when the PAs were bilateral ($P = 0.004$). The rate of limb loss within 1 year of operation was 8.8 per cent; 12.0 per cent for symptomatic and 1.8 per cent for asymptomatic limbs ($P < 0.001$). Risk factors for amputation were symptomatic disease, poor run-off, urgent treatment, age over 70 years, prosthetic graft and no preoperative thrombolysis when the ischaemia was acute. Amputation rates decreased over time ($P = 0.003$). Crude survival was 91.4 per cent at 1 year and 70.0 per cent at 5 years.

Conclusion: Multiple aneurysm disease was common when PAs were bilateral. Preoperative thrombolysis of acute thrombosis and the use of vein grafts for bypass improved outcome.

Paper accepted 25 April 2007

Published online 22 May 2007 in Wiley InterScience (www.bjs.co.uk). DOI: 10.1002/bjs.5755

Introduction

Popliteal artery aneurysm (PA) has been recognized since 200 BC when Antyllus described ligation of the aneurysm followed by packing of the sac¹. Although the exact prevalence of PA is unknown as there is no population-based study, it is the most commonly treated aneurysm after those of the aorta and the intracranial arteries^{2–4}. PA is more prevalent among men and often associated with abdominal aortic aneurysm (AAA) and other peripheral aneurysms^{3,5}. No single surgeon or institution has enough patients to study the epidemiology of this disease.

The aim of treatment for PA is to prevent thromboembolism and subsequent amputation⁵. Amputation rates of 20–36 per cent have been reported among patients with a thrombosed PA^{6–8}. The patient typically presents with acute lower extremity ischaemia, distal embolization, or local symptoms in the popliteal region, occasionally with rupture^{2,4,5}.

The Swedish Vascular Registry (Swedvasc)¹ started in 1987 and since 1994 more than 90 per cent of the vascular surgical procedures performed in Sweden have been registered prospectively⁹, offering a unique opportunity to study a large group of unselected patients. The aim of this study was to review a large group of patients to examine the epidemiology of PA, including the prevalence of other associated aneurysms and the outcome of treatment, with special emphasis on risk factors for amputation.

Methods

By November 2002, 110 000 vascular surgical procedures (both open and endovascular) had been registered prospectively in the Swedvasc. Among these, there were 1231 interventions for an infrainguinal aneurysm. All 42 institutions performing vascular surgery in Sweden participated in the present study and supplied

the investigators with 1160 complete patient files (94.2 per cent). The principal study investigator visited 27 hospitals and analysed 988 records *in situ*; 172 patient files were photocopied for later analysis.

The result of the analysis of patient files is shown in Fig. 1. The 322 non-popliteal operations were mainly for a femoral aneurysm. Another 63 procedures for PA in the contralateral leg, not included among the 1160 procedures, were identified. Among these, 58 procedures were reported to the Swedvasc, but with the indication lower extremity ischaemia rather than aneurysm disease. In all, 141 (96.6 per cent) of the 146 procedures in the contralateral leg were reported to the registry. Thus, this study included data from 717 primary operations for PA, among 571 patients.

In the Swedvasc protocol a large number of variables are registered prospectively, such as indication for surgery, anatomical inflow and outflow, type of operation and graft. Survival, complications, patency, reoperations and amputations are registered after 30 days and at 1 year.

The diagnosis of PA was based on clinical examination, together with an imaging technique in 680 legs (94.8 per cent), and on clinical examination only in 37. Run-off distal to the PA was evaluated by examining the number of patent crural vessels in continuity from the popliteal artery to the ankle¹⁰. If the intervention was performed within 36 h after presentation it was defined as acute; otherwise it was elective. Based on the information in the case notes, including results from different imaging techniques, acute ischaemia from thrombosis of the PA was distinguished from acute ischaemia due to distal embolization to the crural arteries.

A total of 132 patients were treated with thrombolysis, 100 before and 32 during operation. The 100 preoperative thrombolytic treatments transformed 59 open surgical procedures from acute to elective operations.

In January 2005, data were cross-checked against the National Population Registry, resulting in 100 per cent accurate survival data as every Swedish citizen has a unique identity code. Date of amputation and complications were registered prospectively in the Swedvasc and these data were cross-checked against the complete patient records. Leg loss was considered an endpoint if an amputation above the ankle was required during the first year after surgery. All 337 patients alive in January 2005 were invited to participate in a telephone interview; 240 (71.2 per cent) accepted and were asked whether amputation had been necessary. The surgeons responsible for the Swedvasc at the local hospitals checked all remaining 331 patients for information on amputation in orthopaedic case records.

Procedure codes for operations are reported from all hospitals to the Swedish Hospital Discharge Register (SHDR), used for reimbursement; the numbers were compared with the Swedvasc numbers.

Statistical analysis

Differences in proportions were evaluated using the χ^2 test for nominal variables and Kendall's tau-b test for ordinal variables. Student's *t* test was used to evaluate differences in continuous variables. Risk factors were evaluated with relative risk (RR) and 95 per cent confidence intervals (c.i.). The odds ratios of five variables identified as significant risk factors for amputation in univariate analysis were entered into a multivariate logistic regression analysis. Relative

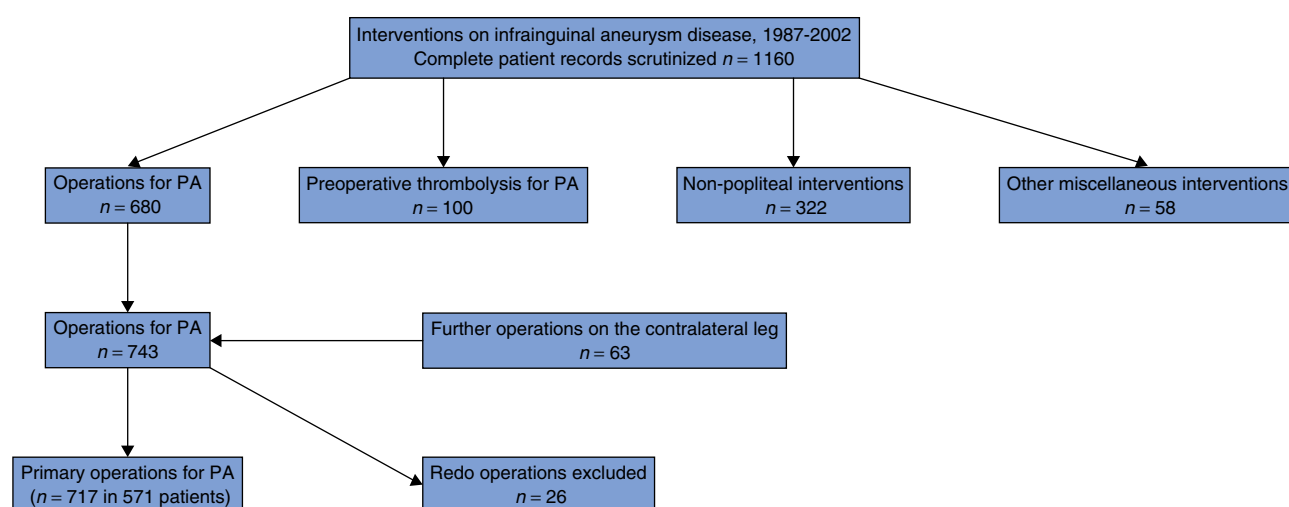


Fig. 1 Study design. PA, popliteal artery aneurysm

survival was calculated by comparing patients with PA with a normal Swedish population of the same age and sex during the same interval. Survival between groups of patients was compared by Cox regression. Survival analysis was performed with SAS software (SAS Institute, Cary, North Carolina, USA) and other statistical analyses were performed with SPSS[®] version 14.0 software (SPSS, Chicago, Illinois, USA).

Results

Among the 571 patients, there were 33 women (5.8 (95 per cent c.i. 3.9 to 7.7) per cent). The median age of the patients was 71 (range 18–94) years. The incidence of operative reconstruction for PA during the interval 1994–2001 was estimated at 8.3 per million person-years.

Swedvasc was compared with the SHDR for 1998, 2000 and 2001. More operations for PA were registered in Swedvasc (38.0, 15.0 and 30.0 per cent respectively). Detailed patient records were available for 94 per cent of the legs at 30 days and 90 per cent at 1 year after intervention. It was possible to supplement data on all patients lost to follow-up either through telephone interview or by cross-checking the orthopaedic files for amputation, resulting in good validity regarding amputation.

Among 717 operated legs, 219 (30.5 per cent) were asymptomatic and 494 (68.9 per cent) were symptomatic (four unknown). Women were more likely to have surgery for symptomatic disease than men (84 *versus* 68.4 per cent, respectively; $P = 0.046$). Treatment was performed urgently in 264 legs (36.8 per cent). The distribution of preoperative symptoms, and correlation between symptoms and the need for acute treatment are shown in *Table 1*.

When the first PA was diagnosed, 266 patients (46.6 per cent) had bilateral PAs: 28 had surgery before the start of the study interval, 146 during the study and 92 did not have surgery before 2004. The time interval between the ipsilateral and contralateral operations varied: 73.3 per cent had surgery within 1 year, 91.8 per cent within 3 years and 97.9 per cent within 5 years.

Patients with a unilateral PA had the following other arterial aneurysms at the time of surgery: aortic 28.1, iliac 8.4, femoral 9.4, others 1.3 per cent. Patients with bilateral PAs had other aneurysms more frequently (46.8 *versus* 34.8 per cent, $P = 0.004$): aortic 37.4 per cent ($P = 0.019$), iliac 12.1 per cent ($P = 0.144$), femoral 14.3 per cent ($P = 0.067$), others 1.5 per cent ($P = 0.863$).

Information on PA size was available for 528 legs (73.6 per cent). The median diameter was 30 (range 10–150) mm. The aneurysms were more often symptomatic in the first operated (ipsilateral) legs, than in the contralateral legs (79.0 *versus* 27.0 per cent $P < 0.001$) (*Fig. 2*). Both small and large PAs were frequently symptomatic, whereas the medium-sized ones were often asymptomatic. Most aneurysms smaller than 15 mm that had surgery were symptomatic (80.5 per cent). Acutely treated legs had larger PAs (mean diameter 35 *versus* 30 mm; $P = 0.004$). Among 623 legs for which this information was recorded, 96.6 per cent had more than 2 mm of thrombus in the wall of the PA, the same as the proportion in subjects with asymptomatic PAs smaller than 20 mm.

Surgical procedure

The most common surgical procedures were exclusion of the aneurysm through a medial approach followed by a bypass (621 legs, 86.6 per cent) and repair with an inlay interposition graft, through a posterior approach (60, 8.4 per cent). Endovascular stent grafts were employed in

Table 1 Symptoms among ipsilateral and contralateral legs that had acute or elective treatment

	No. of legs	Distal embolization	Acute thrombosis	Deep vein thrombosis	Rupture	Critical limb ischaemia	Claudication	Local symptoms	Asymptomatic
Operation									
Ipsilateral	571	164 (28.7)	152 (26.6)	41 (7.2)	24 (4.2)	51 (8.9)	69 (12.1)	66 (11.6)	114 (20.0)
Contralateral	146	9 (6.2)	17 (11.6)	0 (0)	0 (0)	10 (6.8)	9 (6.2)	3 (2.1)	105 (71.9)
$P^{\dagger}$		< 0.001	< 0.001	< 0.001	0.008	0.507	0.038	< 0.001	< 0.001
Treatment									
Acute*	264	118 (44.7)	131 (49.6)	16 (6.1)	24 (9.1)	12 (4.5)	18 (6.8)	13 (4.9)	0 (0)
Elective	453	55 (12.1)	38 (8.4)	25 (5.5)	0 (0)	49 (10.8)	60 (13.2)	56 (12.4)	219 (48.3)
$P^{\dagger}$		< 0.001	< 0.001	0.287	< 0.001	0.005	0.007	0.068	

Values in parentheses are percentages. Ipsilateral operation, the patient did not have previous surgery for popliteal artery aneurysm (PA); contralateral, the patient previously had repair of a PA in the other leg. In 75 legs more than one symptom was present, which explains why the sums of the percentages exceed 100. *Acute treatment was performed within 36 h of presentation. [†] Students *t* test

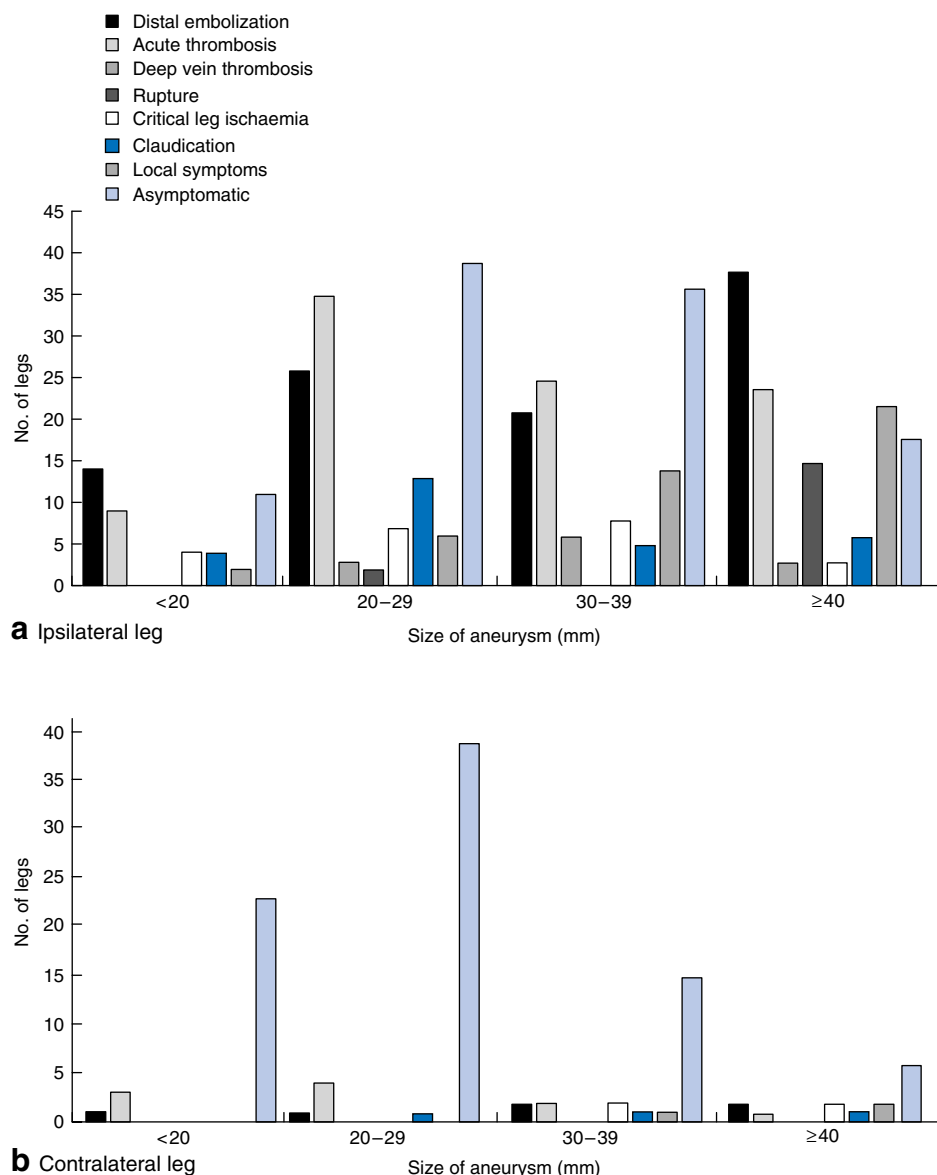


Fig. 2 Distribution of symptoms, according to size of the popliteal artery aneurysm, in 528 legs; **a** ipsilateral (operated first) and **b** contralateral legs

26, one had a venous by-pass through a lateral approach, and miscellaneous other techniques were used in nine legs. Venous grafts were used in 531 of the 679 by-passes (78.2 per cent), among them 181 (34.8 per cent) using the *in situ* method. Among the 148 patients with prosthetic grafts 136 (91.9 per cent) were expanded polytetrafluoroethylene (ePTFE), nine were Dacron® and three were composite ePTFE and vein. In three patients information on the type of graft used was missing. Aneurysm exclusion through both proximal and distal ligation was performed in 531

legs, a single distal ligation in 59 legs, and in 26 legs the aneurysm was excluded by an endovascular technique. This information was missing for 101 legs (14.1 per cent).

The bypass was placed either in a deep anatomical position (45.2 per cent) or more superficially (54.8 per cent). Inflow was taken from the common femoral artery (16.5 per cent), superficial femoral artery (46.8 per cent) or the popliteal artery above the knee (34.9 per cent). The outflow artery was the popliteal artery below the knee (81.6 per cent) or a crural artery (18.4 per cent).

Table 2 Risk factors for amputation within 1 year

	Amputation rate*	Odds ratio†		P‡
		Unadjusted	Adjusted§	
All legs	63 of 717 (8.8)			
Treatment				
Elective	18 of 453 (4.0)	1‡		
Acute (< 36 h)	45 of 264 (17.0)	5.0 (2.8, 8.8)	2.7 (1.3, 5.5)	0.006
Presentation				
Asymptomatic	4 of 219 (1.8)	1‡		
Symptomatic	59 of 492 (12.0)	7.2 (2.6, 20.0)	2.9 (0.8, 10.8)	0.110
Run-off (no. of calf vessels)				
2–3	27 of 535 (5.0)	1‡		
0–1	29 of 103 (28.2)	7.4 (4.1, 13.0)	4.5 (2.3, 8.5)	< 0.001
Age (years)				
≤ 70	16 of 353 (4.5)	1‡		
> 70	47 of 364 (12.9)	3.1 (1.7, 5.6)	2.2 (1.1, 4.4)	0.020
Graft type				
Vein graft	33 of 531 (6.2)	1‡		
Prosthetic#	27 of 174 (15.5)	2.8 (1.6, 4.8)	2.9 (1.5, 5.5)	≤ 0.001

Values in parentheses are *percentages or †95 per cent confidence intervals. ‡Reference group. §Logistic regression model including all risk factors in the table. ¶Likelihood ratio test, multivariable analysis. #The prosthetic grafts were 148 by-passes and 26 endovascular grafts.

Thrombolysis was performed before surgery in 100 and during operation in 32 legs.

Outcome

At 30 days 5.7 per cent of limbs had been amputated, 12.2 per cent had residual ischaemic symptoms, 3.7 per cent had other symptoms (neurological impairment, haematoma, seroma or infection) and 72.6 per cent were asymptomatic (data missing for 5.8 per cent).

One year after surgery, 703 (98.3 per cent) of the 717 operated limbs were available for follow-up (nine patients had died and five were lost to follow-up). Among them, the primary patency rate of the graft was 90.9 per cent and the secondary patency rate was 92.2 per cent.

Risk factors for amputation at 1 year after surgery are shown in Table 2. To adjust for confounding, multivariable analysis was performed by logistic regression. In a subgroup analysis of 235 legs that presented with acute ischaemia, 135 legs that had immediate surgery had a higher risk of amputation at 1 year than the 100 legs that had thrombolysis before surgery (27 *versus* 7.0 per cent; RR 3.8 (95 per cent c.i. 1.8 to 8.2))¹¹.

Patients who had thrombolysis on the operating table had a risk of amputation: 10 of 32 patients (31 per cent) underwent amputation within 1 year.

Time trends in outcome were analysed in three time intervals: 1987–1993 (160 legs), 1994–1997 (259) and 1998–2002 (298). Swedvasc was started as a regional vascular registry and reached national coverage only

by 1994, so the first time interval was prolonged to have a sufficient sample for meaningful comparison. The amputation rates were 13.7, 9.7 and 5.4 per cent respectively ($P = 0.003$). When only patients treated acutely (within 36 h) were analysed (264 legs), amputation occurred in 25.4, 16.8 and 12.0 per cent respectively ($P = 0.035$).

The absolute (crude) survival rate was 98.8 per cent at 30 days, 91.4 per cent at 1 year and 70.0 per cent at 5 years. The relative survival rate compared with a normal age- and sex-matched Swedish population during the interval was decreased by 3.1 (95 per cent c.i. 0.9 to 5.3) per cent at 1 year, 12.9 (95 per cent c.i. 7.8 to 18.0) per cent at 5 years and 17.7 (95 per cent c.i. 8.4 to 27.0) per cent at 10 years. Patients who had urgent surgery had an increased late mortality rate compared with those treated electively (RR 1.59, 95 per cent c.i. 1.19 to 2.12).

Discussion

This observational study was based on prospective reporting from the vascular institutions in Sweden, supplemented by review of patient records. Complete records were retrieved in 94.2 per cent. A crucial issue is whether the validity of the register was sufficient to permit conclusions, or if bias was introduced owing to unreported patients. This does not seem to be a problem, as 15–38 per cent more patients were reported to the Swedvasc than to the SHDR. Patients often need bilateral surgery, and so registration of contralateral

operations could be validated. In all, 141 (96.6 per cent) of the 146 contralateral procedures were reported to the Swedvasc. Missing patients or operated legs were thus uncommon. The Swedvasc has been validated previously, showing that core surgery such as AAA repair^{12,13}, carotid endarterectomy^{14,15} and femoropopliteal bypass¹³ are reported in more than 90 per cent, and with great validity of data.

Previous reports on PA are mostly retrospective studies from single institutions with a timespan of decades^{4,16–20}. There has been one prospective multicentre study on 137 patients with PA treated either surgically or conservatively²¹. The true prevalence of PA remains unknown, because no population-based study exists. Furthermore, the underlying condition is not always recognized in patients with acute or chronic ischaemia secondary to PA. From the present data the incidence of surgical repair of PA could be estimated (8.3 per million person-years), but this is probably an underestimate.

AAAs occur predominantly in men and this pattern is even more pronounced for PA. The relative frequency of PA needing surgery in women is low, varying from 2 to 15 per cent^{19,21}. In the present study 5.8 per cent of PAs were in women. In comparison, 15 per cent of operations for AAA and reported to the Swedvasc²² are in women, but 30 per cent of those who die from a ruptured AAA²³ in Sweden are female. The patient characteristics were similar between men and women, with one exception: women were more likely to have surgery for symptomatic disease. This may reflect a failure to diagnose or a tendency to underestimate PA in women, similar to observations regarding AAA²⁴.

The PAs were bilateral in 46.6 per cent and 34.3 per cent also had an AAA at the time when the first PA was diagnosed. A previous review based on 29 reports published between 1980 and 1995, which included 1673 patients with 2445 PAs, reported that 50 per cent of patients had bilateral PAs and 37 per cent an AAA². In the present study it was possible to distinguish between patients with unilateral and those with bilateral disease. The latter more frequently had an AAA, as well as extrapopliteal aneurysms in general. Patients with multiple aneurysms are of particular interest when investigating the aetiology and pathogenesis of aneurysm disease.

Elective treatment of small PA is controversial. Previous investigators have speculated on the relationship between symptoms and aneurysm size^{17,25}. In this study, 75 per cent of PAs smaller than 20 mm were symptomatic at primary operation, and 15 per cent when the contralateral limb was treated (*Fig 2*). Many small PAs are treated conservatively,

not without risk of acute thromboembolic complications (*Fig. 2*). Unfortunately, the exact risk cannot be estimated from this sort of review.

Conservative treatment with ultrasonographic surveillance has been recommended for asymptomatic PAs smaller than 20 mm^{26–28}. The fact that 80.0 per cent of the treated PAs smaller than 15 mm in this study were symptomatic reflects the reluctance among most surgeons to operate on small asymptomatic PAs. Others argue that, because thrombolysis is not always effective, silent embolism may occlude the infrapopliteal arteries, and an expectant policy is not justified^{17,21,26,29,30}. Furthermore, thrombolysis for acute ischaemia is not without risk. Major haemorrhage and stroke have been reported^{31,32}, although in the present study no such events occurred among 132 treated patients.

Aneurysm thrombosis may be unrelated to size^{25,33}, and the presence of thrombus within the aneurysm could be a better predictor of complications²⁷. In this study 96.4 per cent of asymptomatic aneurysms smaller than 20 mm had more than 2 mm of mural thrombus within the aneurysm.

The main aim of treating PA is to prevent ischaemia and amputation. If possible, emergency operation should be avoided and the run-off be improved by preoperative thrombolysis. Previous investigators have reported good results from thrombolysis of PA, but in small series^{34–36}. In this study run-off was improved dramatically in most of the 100 treated legs. It should be emphasized that thrombolysis is used to improve run-off, not to open a thrombosed PA. Preoperative thrombolysis should not be confused with intraoperative thrombolysis, which is performed in the acute situation when surgery is needed owing to the threat of immediate limb loss. Thrombolysis on the operating table under these conditions was less effective in the present study, and 31 per cent later underwent amputation.

Multiple aneurysms are common, particularly in patients with bilateral PAs. Relative survival is substantially decreased compared with the general population. Poor run-off, the strongest risk factor for amputation, may be improved by preoperative thrombolysis in the acute situation. Amputation rates in Sweden have decreased over time as the results of treatment have improved.

Acknowledgements

The authors thank the participating vascular surgeons from 42 hospitals, and Professor Thomas Troëng, Blekinge Hospital, Karlskrona, for help with validation procedures.

Survival analysis was performed by Lina Benson, Regional Oncological Centre, Uppsala.

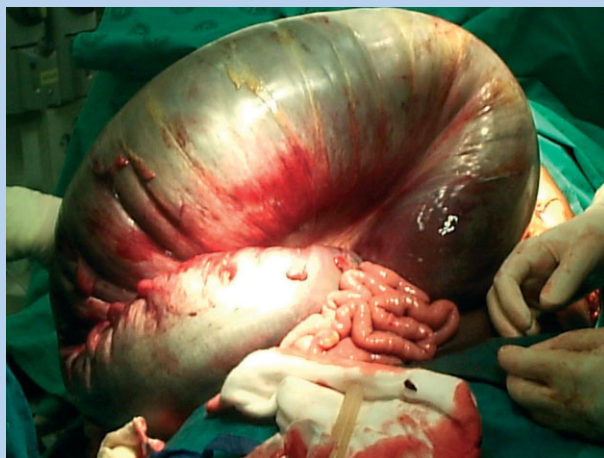
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Sigmoid Volvulus

This intra-operative image shows a massive gangrenous sigmoid volvulus with signs of impending rupture. Patients who develop sigmoid volvulus in the industrialised world tend to be older, and a third of patients either have mental illness or are institutionalised. Initial treatment involves correction of fluid and electrolyte imbalance followed by endoscopic decompression. Indications for emergency laparotomy include clinical signs and symptoms of colonic ischaemia, failed decompression and clinical features suggestive of colonic ischaemia at colonoscopy.



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