Venous Haemodynamics and the Occurrence of Leg Oedema in Patients with Popliteal Aneurysm

Rune Haaverstad¹, Reidun Fougner² and Hans O. Myhre¹

¹Department of Surgery, ²Department of Radiology, University Hospital of Trondheim, N-7006 Trondheim, Norway.

Objectives: To see whether popliteal aneurysms cause venous obstruction and to investigate leg oedema and DVT following repair.

Design: Prospective open clinical study.

Setting: University Department of Surgery.

Materials: 8 patients undergoing popliteal aneurysm repair in 9 legs (1 bilateral repair).

Chief outcome measures: CT and plethysmographic evidence of vein compression, the occurrence of postoperative leg oedema and phlebographic evidence of deep venous thrombosis (DVT).

Main results: Preoperative CT investigation showed that the aneurysm compressed the popliteal vein in 6/9 limbs where surgery was planned and in 9/10 limbs with popliteal aneurysms (patent or occluded) of > 2 cm diameter (p < 0.01). However, on the CT image, increased collateral network could be observed and most patients had normal venous drainage prior to operation as assessed by air plethysmography. Postoperatively, leg volume was measured by the formula of a truncated cone. Following vascular reconstruction, leg volume increased by 23%. Except for one patient with a confirmed DVT preoperatively, postoperative venous congestion and DVT was not observed in the operated leg as assessed by phlebography and plethysmography.

Conclusions: Popliteal artery aneurysms > 2 cm diameter usually compress and dislocate the popliteal vein prior to operation. However, sufficient venous drainage is maintained, possibly because of an increased collateral venous network. Disruption of lymph channels with secondary lymphoedema is probably the most important mechanism behind the leg swelling observed in patients following popliteal aneurysm repair.

Key Words: Popliteal aneurysm; Computed tomography (CT); Venous haemodynamics; Vein compression; Leg oedema; Deep venous thrombosis (DVT).

Introduction

More than 10% of popliteal aneurysms cause local symptoms due to compression of neighbouring structures. These symptoms include: pain in the popliteal region, neuralgia from pressure on the tibial nerve, deep venous thrombosis (DVT) or leg swelling caused by obstruction of venous return.¹⁻⁵ DVT, following surgical treatment of popliteal aneurysms, is supposed to be a common complication.⁶,⁷ However, ipsilateral leg oedema following popliteal aneurysm repair is commonly seen without concomitant DVT.⁸⁻⁹ Leg oedema is a well known complication following infrainguinal arterial reconstruction for peripheral arterial occlusive disease (PAOD) reaching its maximum about one week postoperatively.⁹,¹⁰ However, in contrast to patients with PAOD, most patients with popliteal aneurysms have a patent distal arterial tree.⁴,¹¹

The aim of this study was to see whether popliteal aneurysms cause venous obstruction by compression or dislocation of the popliteal vein and to investigate the occurrence of leg oedema and DVT postoperatively following arterial reconstruction.

Material and Methods

Eight patients presented with a clinical diagnosis of popliteal artery aneurysm. The median age was 74 years (range 50–81 years). The sex ratio male to female was 7:1. Two patients felt discomfort from a pulsating mass in the popliteal fossa and one of these also
Leg Oedema in Patients with Popliteal Aneurysms

Fig. 1. The principle of air plethysmography for detecting venous obstruction. During inflation of a venous occlusion cuff (VOC) (50 mmHg) on the thigh, the leg veins will become dilated and the calf volume will increase. The volume change is obtained by recording cuff (RC) on the leg. In the figure a venous thrombosis is seen distally in the femoral vein. Following deflation of the venous occlusion cuff, the calf volume decreases rapidly in healthy controls (C) and more slowly in patients with an obstruction (O) of the deep veins. Maximum venous emptying rate (VER) was calculated from a line parallel to the first part (1 s) of the emptying curve following release of the venous occlusion cuff.

Investigations

The diagnosis of popliteal aneurysm was verified by digital subtraction angiography (DSA) in all of the patients. The tibial arteries as well as the foot arcade were included in the angiograms. The DSA images were evaluated by an experienced radiologist (R.F.) who did not know the result of the clinical evaluation. Patent distal arteries were found in seven of the limbs scheduled for surgery. In the two patients with ischaemia distal occlusion of all the tibial arteries was demonstrated.

CT investigation was performed preoperatively in all patients with a General Electric 9800 whole body scanner with a scan-time of 3 seconds. Ten millimetre thick slices were obtained through the entire popliteal region. A bolus of 40 ml of contrast medium (Omnipaque® 350 mg/ml) was injected into a peripheral foot vein bilaterally. The extent and size of the aneurysm as well as compression, dislocation and patency of the popliteal veins were evaluated from the CT images. The CT investigation lasted for approximately 10 minutes.

In order to get a functional measure of the venous drainage of the limbs, air plethysmography (Stranden Pletysmograph, STR-Teknikk, Oslo, Norway) was performed bilaterally. In seven patients both legs were examined preoperatively and at a median of 7 days following operation. Following deflation of a venous occlusion cuff (50 mmHg) on the thigh, changes in the leg volume were obtained by an air filled recording cuff applied on the leg. With the paper speed of the recorder fixed at 10 mm/s, maximum venous emptying rate (VER) was calculated from a line parallel to the first part (1 s) of the emptying curve (Fig. 1). Values below 15 mm/s as well as a difference in VER between the legs of more than 15 mm/s were considered pathological. In two cases this investigation was not performed due to technical difficulties. The ankle-brachial blood pressure index (ABPI) was measured pre- and postoperatively by the Doppler technique. Leg volume increase was calculated 7 days postoperatively according to the formula of a truncated cone after measurement of the leg circumference 5–7 cm above the medial malleolus and at the greatest circumference, 25–28 cm proximal to the medial malleolus.

The patency of the deep veins was investigated by bilateral ascending phlebography in seven cases at a median 6 days postoperatively. The patient with bilateral operations was investigated by phlebography following the second operation and by plethysmography only following the first procedure. The patient who presented with a ruptured popliteal aneurysm was excluded from the postoperative investigation program except from measurement of ABPI, since he required intensive care treatment for septicemia. All patients had given their informed consent for participation in the study.

Eur J Vasc Endovasc Surg Vol 9, February 1995
Table 1. Preoperative CT investigation in patients with popliteal aneurysm indicating extent, maximum external diameter and compression of the popliteal vein. Operation of case no. 7 and 8 was done bilaterally with an interval of 1 year

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Extent of the aneurysm in the popliteal artery (P = proximal, M = middle, D = distal)</th>
<th>External diameter of the aneurysm (cm)</th>
<th>Popliteal vein compression from the aneurysm (+/-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P + M</td>
<td>3.8</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>P + M</td>
<td>3.5</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>P + M</td>
<td>2.4</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>3.6</td>
<td>+</td>
</tr>
<tr>
<td>5</td>
<td>P + M</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>P + M + D</td>
<td>1.6</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>P + M</td>
<td>3.0</td>
<td>+</td>
</tr>
<tr>
<td>8</td>
<td>P + M</td>
<td>2.1</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>P + M</td>
<td>5.0</td>
<td>+</td>
</tr>
</tbody>
</table>

Median (range): 3.0 (1.6-5.0)

**Operation**

All operations were done via a medial approach above and below the knee. The arterial reconstruction was performed with either a short femoropopliteal bypass following ligation of the popliteal artery below and above the aneurysm (n = 7) or by an interposition graft (n = 2). Autologous greater saphenous vein was preferred for the reconstruction and used in eight operations. The veins were usually taken from the same limb (n = 6). However, in cases with signs of preoperative venous obstruction, the contralateral greater saphenous vein was used (n = 2). One patient received a 6mm PTFE (GoreTex®) graft because of poor quality vein. In three patients with large aneurysms (3.0, 3.6 and 5.0 cm, respectively), the aneurysmal wall was resected and the thrombus evacuated. In one of these patients the aneurysm was infected and ruptured.

Postoperatively all patients received intravenous dextran 70 (Macrodex®) routinely; 500 ml on the day of operation, as well as 500 ml on the 1st postoperative day as prophylaxis against venous thrombosis.

**Results**

The preoperative CT investigation showed that eight of the aneurysms scheduled for surgery included the proximal as well as the middle part of the popliteal artery. In one patient the aneurysm extended distally to the trifurcation of the popliteal artery. Another patient presented with an aneurysmal dilatation of the middle segment only. In patients with bilateral disease, the extension of the disease was fairly symmetrical. The median external diameter of the operated aneurysms (n = 9) was 3.0 cm (range 1.6-5.0 cm) (Table 1). The median external diameter of the contralateral popliteal aneurysms (patent and occluded; n = 8) was 2.0 cm (range 1.0-5.0 cm).

There was compression of the popliteal vein by the aneurysm in six of the limbs where surgery was planned (Table 1) and in four of the contralateral limbs. Venous compression was observed in all aneurysms exceeding 3 cm in diameter and in 9/10 popliteal aneurysms (patent and occluded) of > 2 cm diameter (Fig. 2). In contrast, venous compression was observed in only one aneurysm ≤ 2 cm (p < 0.01). Nine aneurysms also dislocated the popliteal vein in the dorsal direction (Fig. 3). In one patient the CT investigation revealed a ruptured popliteal aneurysm of 5 cm in diameter, as well as an occluded popliteal vein (Fig. 4). None of the other patients presented with DVT preoperatively. However, in patients with severe compression of the popliteal vein, the CT image showed ipsilateral dilatation of the greater saphenous vein (Fig. 2) or increased collateral venous network (Fig. 4).

**Statistics**

The values are given as median and range. The statistical calculations were based on the Wilcoxon signed rank test for paired data and Fischer’s exact probability test. A confidence level of < 5% was considered significant. NS = not statistically significant.
Preoperatively, air plethysmography showed normal drainage of the deep veins bilaterally in six out of seven investigated patients. In only one patient with a 3.5 cm aneurysm was the venous emptying rate reduced (5 mm/s) in the symptomatic limb, compared to a normal rate (50 mm/s) in the contralateral leg.

Postoperatively, plethysmography was normal bilaterally in all of the other seven cases.

Postoperatively, ABPI was unchanged on the operated side, with median 1.06 (range 0.76–1.20) before treatment and median 1.04 (range 0.58–1.20) following the arterial reconstruction (NS). The median
Fig. 4. CT of case no. 9 with a ruptured popliteal aneurysm of 5.0 cm diameter on the left side. The popliteal vein is occluded and there is increased collateral venous network medially. On the right side there is a patent popliteal aneurysm of 3.0 cm diameter with the typical finding of dorsal compression and dislocation of the popliteal vein (arrowed).

Leg volume increased significantly in the operated limbs to a maximum of 23.4% (range 4.4–32.0%) 7 days postoperatively (p < 0.02; Table 2). Except from the patient with a confirmed DVT preoperatively, postoperative DVT was not observed on the operated side neither by phlebography (n = 7) nor by plethysmography (n = 1). However, in the non-operated limb, two patients with bilateral aneurysms developed postoperative DVT of the tibial and popliteal veins, respectively (Table 2).

**Discussion**

Computed tomography is a useful method for the study of popliteal aneurysms and surrounding structures.\(^{11,16}\) Earlier reports have shown that a popliteal aneurysm can lead to compression and even thrombosis of the popliteal vein especially when the aneurysm diameter exceeds 5 cm.\(^{17}\) The present CT investigation show that prior to operation most of the popliteal aneurysms of diameter greater than 2 cm and all above

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Leg volume increase (%)</th>
<th>Operated limb</th>
<th>Operated limb</th>
<th>Contralateral limb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23.5</td>
<td>N</td>
<td>N</td>
<td>DVT</td>
</tr>
<tr>
<td>2</td>
<td>23.2</td>
<td>N</td>
<td>N</td>
<td>DVT</td>
</tr>
<tr>
<td>3</td>
<td>16.2</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>31.2</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>5</td>
<td>27.3</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>15.2</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>7</td>
<td>32.0</td>
<td>N(^1)</td>
<td>N(^1)</td>
<td>N</td>
</tr>
<tr>
<td>8</td>
<td>4.4</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Median (range): 23.4 (4.4–32.0)
3 cm compressed and dorsally dislocated the popliteal vein with dilated collaterals. However venous drainage as assessed by air plethysmography was normal in 6/7 investigated patients.

In cases where aneurysm wall resection and evacuation of the thrombus is performed, as in three of our patients, venous compression from the aneurysm is eliminated. However, when the aneurysm is simply excluded, there may still be a possibility of continued compression of the popliteal vein. During surgery for popliteal aneurysms in patients with suspected venous obstruction, one should therefore be aware of the function of collateral veins. Use of the contralateral greater saphenous vein as graft material should be considered, especially in cases where unilateral operation is indicated.

It would have been ideal to repeat the CT investigation postoperatively, but this was not possible. However, because of the postoperative leg oedema it was decided to perform postoperative phlebography to investigate venous haemodynamics and the occurrence of deep venous thrombosis. Minor DVT or obstruction of venous flow occurred in only two limbs with non-operated popliteal aneurysms. We could therefore not confirm earlier reports of DVT6,7 as a common complication following popliteal aneurysm repair. In addition, plethysmography was found to be normal postoperatively in the operated limbs. These data support the view that the venous drainage from the lower extremity is normal in the postoperative period and seems to exclude venous obstruction as a cause of postreconstructive leg swelling in patients following popliteal aneurysm repair.

The degree of leg oedema was of the same magnitude as observed following infrainguinal operations for PAOD.9,10 Impaired lymph drainage,18-20 increased capillary filtration rate21-23 and reperfusion syndrome24,25 have been suggested as mechanisms responsible for the postreconstructive leg oedema formation. In the present study angiography showed distal occlusion of the tibial arteries in only two patients, probably caused by distal embolisation from thrombus within the aneurysm. Leg oedema following surgery for PAOD has been suggested to be partly related to preoperative ischaemia.23 This factor is unlikely to be the cause of leg swelling in patients operated on for popliteal aneurysm. If preoperative ischaemia played a part in the production of leg oedema, one would expect that oedema would be less pronounced in this group.

Lymphoedema has been suggested as the main mechanism for the postoperative leg oedema following popliteal aneurysm repair.8 Investigators using lymphoscintigraphy have found a significant correlation between the appearance of leg oedema and disruption of lymph channels following femoro-popliteal bypass surgery. The lymphatic interruption is seen proximally in the thigh, distally in the popliteal region and in the calf.19,20 Furthermore virtually all postreconstructive leg oedema is restricted to the subcutaneous tissue and we have previously shown by MRI investigations that the leg muscles are unaffected following arterial reconstruction for obliterator atherosclerosis.10 The present findings therefore support the view that acute lymphoedema may be the dominant cause of leg oedema following popliteal aneurysm repair.

In conclusion, popliteal artery aneurysms > 2 cm in diameter usually compress and dislocate the popliteal vein prior to operation. However, the preoperative venous drainage from the limb is usually normal because of an increased collateral venous network. We believe that disruption of lymph channels with secondary lymphoedema is probably the most important mechanism behind the postoperative leg oedema observed in this group of patients.

References


Accepted 18 August 1994.