Endurance Athletes with Intermittent Claudication Caused by Iliac Artery Stenosis Treated by Endarterectomy with Vein Patch – Short- and Mid-term Results

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WHAT THIS PAPER ADDS

- Diagnosis and treatment of endurance athletes with intermittent claudication are challenging. Conventional vascular testing is not discriminative in endurance athletes and general treatment strategies do not apply to this patient group.
- Our study describes in detail diagnostic workup, treatment and follow-up of 36 endurance athletes with intermittent claudication due to iliac artery stenosis treated with endarterectomy with vein patch and is the first study in literature describing this treatment with a complete middle-term follow-up.

ARTICLE INFO

Article history:
Received 30 September 2011
Accepted 4 January 2012
Available online 20 January 2012

Keywords:
Iliac stenosis
Endoﬁbrrosis
Endarterectomy
Vein patch
Endurance athletes
Cyclists

ABSTRACT

Introduction: Endurance athletes may suffer from intermittent claudication. A subgroup of 16% has severe iliac artery stenosis due to endoﬁbrrosis. In this study we report the short- and mid-term results of endarterectomy with venous patching.

Patients/methods: Athletes with claudication-like complaints were analysed using a protocol including cycling test and provocative echo-Doppler. Thirty-six athletes were diagnosed with serious iliac ﬂow limitation (one bilateral), conﬁrmed by additional magnetic resonance (MR) angiography. Endarterectomy with venous patching was performed for 32 iliac artery stenosis and ﬁve occlusions. Postoperative (mean 15.6 months) 33 legs were evaluated using the same diagnostic protocol. A complete follow-up after mean 29 months was obtained by questionnaire.

Results: Twenty-eight athletes were symptom free or could perform on a desired level with minor remaining complaints. Two athletes were satisﬁed though minor complaints prohibited high competition performance. Two athletes developed a re-stenosis and became symptom free after an additional operation. Three athletes had objective improvement but limited decrease in symptoms. One was unsatisﬁed but refused postoperative tests. The only major surgical complication was a postoperative bleeding necessitating re-operation. Postoperative tests showed signiﬁcant increase in maximal workload and post-exercise ankle–brachial index. No aneurysm formation was detected.

Conclusions: Precise diagnosis and meticulously performed endarterectomy with vein patching have satisfactory results in mid-term follow-up with acceptable risk in endurance athletes complaining of intermittent claudication due to iliac artery stenosis.

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All endurance athletes presenting themselves with complaints of intermittent leg claudication were evaluated with our specific adapted test protocol. In 65% of these patients an iliac flow limitation could be diagnosed. Iliac kinking without stenosis or elongation could be demonstrated in half of these patients; kinking with elongation and a short stenotic segment is present in an additional 25%, whereas the remaining quarter demonstrates severe external iliac artery stenosis or occlusion.

Conservative treatment was advised consisting of counselling, adjustment of the cycling position or switch of sport. However, especially professional cyclists and other athletes performing at high level did consider their complaints highly disabling and were not satisfied with conservative treatment. Operative options were explored by additional contrast enhanced magnetic resonance angiography (CE-MRA).

Athletes with severe external iliac stenosis or occlusion were treated with endarterectomy and a venous patch. In this follow-up study, we evaluate the results of this treatment with special attention to reduction of complaints and risk of dilatation and restenosis.

**Patients and Methods**

**Subjects**

During the study period 1996–2007, 36 of the athletes with severe disabling complaints of typical intermittent claudication with loss of power, cramp or pain were diagnosed to have significant vascular narrowing, dissection or occlusion of the external iliac artery. These patients were operated with endarterectomy and vein patching of the external iliac artery. Of these 36 patients, one was operated on both legs in two separate sessions.

Baseline characteristics of the patients are shown in Table 1. Patients were mostly cyclists (87%) and the majority was male (27 out of 36 patients). They cycled an average of 73,000 km with complaints, indicating a considerable patient and doctor delay. Symptoms were mostly left sided (23 out of 36 patients). About 50% of these patients were active at the national/professional level.

**Preoperative diagnostic testing**

All patients were tested using our specially devised test protocol. A thorough patient history and physical examination were performed with attention to bruits over the external iliac artery (EIA) and common femoral artery (CFA) with extended and flexed hips. A cycling test was performed measuring maximum working capacity, ankle–brachial index (ABI) and the difference in ankle pressure between the healthy and the affected leg. Echo-Doppler examination visualised vascular stenosis and excessive length and allowed measurement of the peak systolic velocity (PSV). Measurements were performed with the hip extended and again with the hip flexed aimed at eliciting kinking of the artery. A CE-MRA (Philips Gyroscan NT 1.0T) was performed with flexed hips facilitating the visualisation of possible kinking of common iliac arteries (CIAs). CE-MRA with extended hips assessed the degree of vascular narrowing and the length of the iliac vessels.

**Operation**

Following informed consent to the specifics of surgery, patients were operated under general anaesthesia by one vascular surgeon in Máxima Medical Centre, the Netherlands. Through an inguinal incision the oblique and transverse abdominal muscles were split in their fibre direction. The lateral portion of rectus abdominis fascia was incised and the iliac artery was approached by extraperitoneal route. The iliac artery was dissected from the aortic bifurcation down to the inguinal ligament. Small side branches to the psoas muscle were transected. The internal iliac artery was dissected over about 4 cm. Damage to the adjacent veins, nerves, ureter and the lymphatic vessels was avoided.

Through a second small groin incision the CFA was dissected cranially up to the EIA. Superficial external pudendal, deep circumflex iliac and inferior epigastric arteries were saved. The EIA was cut in an oblique plane from the iliac bifurcation and exteriorised through the groin incision (Fig. 1a–c). The EIA was opened by a longitudinal incision at its ventral portion followed by an endarterectomy of the stenosed segment. A portion of the saphenous vein was harvested through two separate small incisions on the medial side of the thigh. Integrity of the EIA was restored using a long saphenous vein patch and prolene 5/0 sutures (Fig. 2a,b). The reconstructed EIA was repositioned and re-anastomosed to the iliac bifurcation, with the patch extending over the iliac bifurcation to prevent stenosis at the anastomosis (Fig. 1d,e).

Intimal thickenings were removed and examined by a pathologist, most often revealing endofibrosis. As the athletes did not suffer from atherosclerosis they used aspirin for 3 months only and no statin was prescribed.

**Postoperative diagnostic regimen**

Postoperative control was performed after 2 and 8 weeks, usually by telephone. Patients followed a recovery schedule with increasing exercises. After 2 months training was resumed. Postoperative testing was performed with the same specific test

![Figure 1](Figure 1. External iliac artery stenosis (EIA) corrected by endarterectomy and vein patch (a) EIA stenosis, (b) dissection and trans-section of the EIA at the iliac bifurcation, (c) longitudinal incision after exteriorisation with endarterectomy, (d) reconstruction of the EIA by vein patch, (e) re-anastomosis of the EIA to the iliac bifurcation.)
protocol including echo-Doppler, cycling test and CE-MRA with extended hips after a mean period of 15.6 months (median 7 months). Thus, we obtained preoperative and postoperative values for watt per kilogram, ABI, ankle pressure difference and PSVs with extended and flexed hips.

As either financial or logistic reasons prohibited four patients to return for postoperative testing, postoperative cycling test and duplex examination were available in 33 legs from 32 patients. In addition three patients did not have a postoperative CE-MRA due to financial constraints; thus a postoperative CE-MRA was available in 30 legs.

Complete follow-up by questionnaire was obtained after an average of 29 months (median 19 months).

Statistical analysis

The Wilcoxon signed-rank test of the SPSS 13.0 package was used to determine differences between pre- and postoperative values. A $p$-value <0.05 was considered significant.

Results

Complications

Immediate complications included one postoperative bleeding necessitating re-operation. Patients reported transient hypoesthesia in the operated area ($n = 10$), superficial haematoma ($n = 6$) or and minor superficial inflammation of the wound ($n = 2$). Three patients experienced hypoesthesia in the wound area persisting up to 9 months. Two patients complained of persisting intermittent claudication which proved to be resulting from residual stenosis at the distal end of the patch. They were re-operated after 4 and 11 months, respectively, and became symptom free.

Questionnaire

A 100% follow-up was obtained by a questionnaire after an average of 29 months (median 19 months). Data are summarised in Fig. 3. Thirty patients ($n = 31$ legs, 84%) were satisfied with the operative result. In 19 legs symptoms disappeared completely. In 10 legs minor complaints were experienced but these athletes could perform on the desired level of sport. Two athletes experienced minor persisting complaints but were satisfied with their improved performance level, albeit slightly less than before the start of the claudication.

Six patients (6 legs, 16%) were not satisfied with the operative result. Two patients were successfully re-operated to solve residual stenosis at the end of the patch which ended their complaints. Three patients showed objective improvement in the postoperative cycling test and echo-Doppler, although they were not satisfied due to remaining complaints. One of these three patients underwent a percutaneous transluminal angioplasty (PTA) of a stenosis at the distal end of the patch but this did not resolve his complaints.
Another of these three patients had persisting complaints probably caused by a L5–S1 spondylolisthesis and he was referred to an orthopaedic surgeon. The sixth patient was unsatisfied but did not show up for diagnostic testing, so no postoperative data were available.

Cycling test

Results obtained from cycling tests are shown in Table 2. Financial or logistic reasons prohibited four patients to return for postoperative testing; thus postoperative cycling tests were available for 33 legs. The average maximum working capacity increased significantly from 5.35 W kg\(^{-1}\) before the operation to 5.70 W kg\(^{-1}\) after the operation. The post-exercise ABI improved significantly from preoperative 0.45 to postoperative 0.59. The difference in ankle pressure between the healthy and the operated leg showed significant reduction from 50 to 17 mmHg. Although we miss the postoperative values of four patients we know from the questionnaire that three of them were satisfied with the operative results.

Echo-Doppler

The follow-up with echo-Doppler was performed in 33 of 37 legs. From 22 legs (67%) both the pre- and postoperative values of the measured PSVs were available, as six patients presented with an occlusion or dissection and in another five patients either preoperative or postoperative PSV could not be measured due to technical difficulties. The PSV with hips flexed decreased significantly from 2.39 m s\(^{-1}\) preoperative to 1.66 m s\(^{-1}\) postoperative (p-value 0.001). Data are shown in Table 3.

Preoperatively, in 25 legs, narrowing was detected in the EIA. Six patients presented with an occlusion or dissection. Bowel distension precluded adequate visualisation in one patient and in five patients the stenosis was not detected by echo-Doppler but only from CE-MRA.

After a mean of 16 months in 25 of the 33 patients the diameter of the patched area was 8% to maximally 85% larger than the expected normal diameter of the EIA. In contrast, a partial narrowing at the site of the patch was observed in six patients. The number of kinks with flexed hips in the CIA and the EIA decreased from 29 kinks (22 legs) preoperatively to 12 kinks (10 legs) postoperatively. Only one patient with a postoperative kink had minor complaints.

CE-MRA with extended hip

Preoperative CE-MRA

With the preoperative CE-MRA 31 stenoses were detected in the EIA, whereas one patient had a narrowing from the CIA down to the EIA. Five patients harboured a total occlusion of the EIA. One patient revealed a dissection after successful treatment elsewhere for an occlusion with thrombolysis and PTA.

Preoperative vessel length ratios (vessel length divided by the distance between the respective bifurcations) obtained from CE-MRA are shown in Table 4. Values were obtained in 32 legs as five EIAs were occluded. Vessel lengths of both the CIA and EIA were within normal range as compared to athletes without complaints.\(^7\)

Postoperative CE-MRA

Postoperative CE-MRA was obtained after a mean of 15.6 months in 30 legs. In 24 patients the diameter of the patched area was 10–70% larger than the expected normal diameter of the EIA with an average of 36% (SD 20%). In contrast, a partial diameter decrease was observed in six arteries, especially at the distal end of the patch. One of these patients was treated with PTA because of persisting postoperative complaints, but this did not relieve his complaints. Two other patients who were reoperated at the level of the stenosed distal end of the patch became symptom free.

Discussion

In our hospital we maintain a follow-up study of endurance athletes with intermittent claudication due to iliac flow limitation. The diagnosis of intermittent claudication in endurance athletes is

![Figure 3. Postoperative patient satisfaction (N = 36) after a mean of 29 months.](image)

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Results obtained from cycling tests (N = 33).</th>
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<tbody>
<tr>
<td></td>
<td>Preoperative Mean (SD)</td>
</tr>
<tr>
<td>Watt/kg</td>
<td>5.35 (1.19)</td>
</tr>
<tr>
<td>Ankle–brachial index</td>
<td>0.45 (0.13)</td>
</tr>
<tr>
<td>Ankle pressure difference</td>
<td>30.0 (31)</td>
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</table>
notoriously difficult and doctor’s delay is usually considerable. Health-care providers do not expect the presence of arterial disease in young and highly active athletes. On examination, peripheral pulses are present and no pressure drop is observed in conventional treadmill testing. Accompanying complaints such as lower backache may obscure their claudication and lead to the erroneous diagnosis of a musculotendinous ailment. Fortunately, awareness among specialists, general practitioners, physiotherapists and sport physicians is increasing.\(^2\)

We evaluate all our patients with intermittent claudication using a standardised diagnostic test protocol.\(^3\) With this protocol three major causes of iliac flow limitation may be identified. First, kinking of the iliac artery caused by fibrous adhesions or psoas muscle side branches combined with displacement of the artery due to psoas muscle hypertrophy might lead to functional stenosis on hip flexion. Second, elongation of the iliac artery might lead to kinking. Lastly, stenosis due to endofibrosis is frequently encountered.

Specifically cyclists and speed skaters are at risk for this problem as they combine heavy leg exercise with a strong hip flexion. Half of the athletes request for operative treatment, whereas the other half is initially satisfied with conservative treatment accepting a less intensive level of sports. However, 20% of the conservatively treated patients return in a later stage for operative treatment as they experience their complaints too invalidating.

Treatment must be tailored to the specific cause. Operative treatment for kinking consists of releasing the fibrous adhesions and ligation of psoas side branches.\(^10\) Kinking due to excessive vessel length is preferentially treated by release and shortening of the iliac artery. An accompanying short stenosis is excised especially when excessive length is present. Long external EIA stenosis caused by endofibrosis is treated by endarterectomy and vein patch. All operated athletes are evaluated postoperative with the same dedicated test protocol measuring objective improvement in addition to patient satisfaction.

This article reports a complete follow-up of 36 endurance athletes operated with endarterectomy and vein patch for iliac artery stenosis on short and middle term. The operation turned out to be safe with only one postoperative bleeding necessitating re-operation and a few minor complications, mainly neuropraxia.

Immediate improvement was achieved in 84% of the patients resuming high-level sports. Two additional patients were satisfied after re-operation with a final success rate of 89%. Objective improvement was proved by a statistically significant increase in the maximal workload and the ABI and a significant decrease in the ankle pressure difference and the PSVs. However, values of ABI and PSV did not reach published values obtained in healthy controls.\(^4,5,11\) This discrepancy might be caused by residual stenosis at the end of the patch as encountered in three of our patients. These failures have taught us to extend the vein patch well beyond the stenotic section, whereas special attention is paid to our suturing technique at the end of the patch. Postoperative fibrosis might lead to kinking of the iliac artery as observed in few patients with postoperative duplex scan, although no relation was found with postoperative complaints.

Postoperative measurements were available in 33 out of 37 legs. Four patients were not tested due to financial and logistic restraints, two of them residing abroad (Australia and UK). As all four completed the 29 months postoperative questionnaire and three reported to be satisfied and having resumed high-level sports, there is no indication to assume that the postoperative results are biased.

Vein patch dilatation might occur leading to aneurysm formation as is known from vein patching in carotid artery stenosis.\(^12,13\) Although endurance athletes exert strong repetitive stress onto the vein patch, dilatation of the patched segment was not alarming in our patients after a mean of 16 months. The mean increase in diameter was 36% as observed by CE-MRA, whereas the maximal increase was 70% (and 85% using Duplex). It must be appreciated that a diameter increase is, to a certain extent, intentional as a means to provide a widened iliac artery preventing flow limitation. Nevertheless, late dilatation may occur mandating long-term follow-up. We advise echographic follow-up after 3 years and subsequently at 5-year intervals.

As an alternative treatment option angioplasty seems tempting. However, this has limited success. As endofibrosis is an elastic lesion, it will easily recoil causing early restenosis.\(^14\) Wijesinghe reported on a top-level female cyclist who presented 2 weeks before the start of the 1996 Atlanta Olympics with a typical external iliac syndrome. Because of the short time span between presentation of complaints and the moment of competition, she was treated with balloon angioplasty. The intervention resulted in symptomatic improvement without a fall in the ABI after exercise. However, 6 weeks after the Olympic race the symptoms returned.\(^15\) Other authors confirm that balloon angioplasty only provides short-term relief.\(^16\)

One patient was successfully treated in another hospital by thrombolysis and PTA for an occlusion. Subsequently he presented himself to us with a dissection. The dissection may have been present before the PTA but may also have been caused or aggravated by the PTA. Some authors suggest that dissection occurs easily due to the loose attachment between the endofibrotic intima and the unaffected media. Injury to the intimal layer caused by the high blood pressures generated by vigorous exercise might facilitate dissection and subsequent occlusion.\(^2,16,17\) We consider the risk of dissection of the loosely attached endofibrosis very high and advise against angioplasty in these athletes.

Little is known about stenting in treating arterial stenosis in endurance athletes. The semi-rigid stent will cause severe friction in the vessel wall, especially with repeated hip flexion combined with the high blood pressures and tachycardia present during endurance sports. Restenosis due to intimal hyperplasia, especially at the ends of the stent, is described and may necessitate operative re-intervention.\(^11,17,18\)

### Table 3

<table>
<thead>
<tr>
<th>Vessel length ratio</th>
<th>Preoperative Mean (SD)</th>
<th>Postoperative, mean 15.6 months Mean (SD)</th>
<th>P-value Pre- versus post-operative</th>
<th>Normal range(^8) Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hips extended (m/sec)</td>
<td>1.77 (0.65)</td>
<td>1.49 (0.56)</td>
<td>P = 0.079</td>
<td>1.08 (0.24)</td>
</tr>
<tr>
<td>Hips flexed (m/sec)</td>
<td>2.39 (0.95)</td>
<td>1.66 (0.75)</td>
<td>P = 0.001</td>
<td>1.16 (0.33)</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Vessel length ratio</th>
<th>Preoperative Mean (SD)</th>
<th>Normal range(^7) Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common iliac artery</td>
<td>1.05 (0.06)</td>
<td>1.05 (0.04)</td>
</tr>
<tr>
<td>External iliac artery</td>
<td>1.07 (0.06)</td>
<td>1.08 (0.05)</td>
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Artificial grafts also carry the risk of intimal hyperplasia at the distal anastomosis due to compliance mismatch. This risk might be increased in endurance athletes due to the high strain they pose on their iliac vessels.

We choose endarterectomy with venous patch for iliac artery stenosis in endurance athletes. Until now only case reports are published in the literature. Normalised ABI values with optimal stenosis in endurance athletes. Until now only case reports are reported. Similar short-term results were reported in a second operative evaluation. Our study shows that a meticulously performed endarterectomy with vein patching is safe and successful in endurance athletes with intermittent claudication due to iliac artery stenosis.

Concluding we do realise our study has methodological flaws as only our treatment regimen is evaluated. Other treatments might also be successful. The rare condition of endofibrotic stenosis precludes a prospective randomised study. However, our dedicated test protocol results in an exact diagnosis and a thorough post-operative evaluation. Our study shows that a meticulously performed endarterectomy with vein patching is safe and successful in endurance athletes with intermittent claudication due to iliac artery stenosis.

Conflict of Interest
None.

Funding
None.

References