

ILIAC ARTERY ENDOFIBROSIS IN HIGH-PERFORMANCE ATHLETES

– Written by George Peach and Robert J. Hinchliffe, United Kingdom

Exercise-induced leg pain is a very common symptom and affects a huge variety of patients. It can be caused by a wide range of pathologies and affect many different joints or muscle groups, but when reported by high-performance athletes it can sometimes lead to diagnostic difficulty. This group is typically involved in high-intensity or high-impact sports where physical injury is common and pain is often attributed to musculoskeletal causes. It is only when symptoms fail to resolve despite standard therapy regimens that other potential causes are sought. This article focuses on a frequently overlooked cause of leg pain in young athletes – iliac artery endofibrosis (IAE).

The possibility that lower-limb pain could be caused by non-atherosclerotic arterial disease was first suggested almost 30 years ago, when Chevalier reported findings from

a cohort of elite cyclists presenting with calf pain provoked by maximal exertion. In their study, symptomatic individuals were found to have localised flow limitation within the iliac arteries and histological examination of excised arterial segments demonstrated pathological thickening of the vessel intima: ‘endofibrosis’¹. Despite these findings, there have been relatively few reports of the condition during the intervening decades. This may be because the phenomenon is under-recognised, because a clear schema for its diagnosis and management has been elusive.

Although it has most commonly been reported among competitive cyclists, endofibrosis has also been found to occur in other athletes, including endurance runners, speed skaters, cross-country skiers and weightlifters. The incidence appears to be far greater in men than in women and

affected individuals are typically less than 40 years of age, although cases have been reported in patients as old as 61. The common link between affected individuals seems to be that they have all been involved in high-intensity endurance training – particularly of the sort that involves repetitive flexion and extension of the hip.

While recognition of IAE is increasing, many sports centres, physicians and vascular specialists remain relatively unfamiliar with the condition and its investigation, which can lead to delays in diagnosis and potentially incorrect treatment.

AETIOLOGY

The mechanism by which repetitive hip flexion leads to iliac artery endofibrosis is not well understood and is likely to be multifactorial. A number of anatomical and physiological factors are thought to be



Figure 1: An angiogram demonstrating narrowing of the left external iliac artery due to endofibrosis.

contributory to pathological changes in the arterial wall. These factors, either alone or in combination, cause mechanical trauma to the vessel wall, stimulating endofibrosis. At a histological level, the fibrotic process involves subendothelial accumulation of loose connective tissue consisting of collagen, elastin and smooth muscle cells. The media and adventitia of the vessel are usually unaffected. This process is quite distinct to atherosclerosis, in which collagen is densely packed and calcification is usually widespread.

While IAE predominantly affects the external iliac artery (Figure 1), fibrosis also extends into the common femoral artery in a significant proportion of cases and may even reach the profunda femoris artery on occasion (with isolated cases of profunda dissection and occlusion having been

reported)². Involvement of the common iliac arteries has also been described.

Of the athletes most commonly affected, it seems that it may not simply be repetitive hip flexion per se that is important, but also the degree of hip flexion involved in the sport. Just as the biomechanics of any sport can lead to a characteristic constellation of injuries, the extreme flexion of the hip seen in cycling, speed-skating and weightlifting is thought to cause excessive stretching of the iliac vessels anterior to the hip joint, stimulating endofibrosis in susceptible individuals. This phenomenon of arterial deformation may be exacerbated by hypertrophy of the psoas major and other hip flexors. Muscular hypertrophy increases arterial displacement and thus the potential for extrinsic compression of the artery as it passes beneath the inguinal ligament.

However, the exact role of the inguinal ligament in the aetiology of IAE remains unknown. Importantly, any compression of the external iliac artery by the inguinal ligament is not thought to be sufficient to cause flow limitation in itself, but may be enough to stimulate endofibrosis. Indeed, though it may be association rather than causation, it has been shown that individuals with unilateral leg symptoms have significantly greater thigh circumference on the affected side^{1,3}. It has also been suggested that affected individuals may have small aberrant arterial branches or additional connective tissue that immobilise the external iliac artery, preventing normal movement of the artery and increasing the trauma caused by repetitive hyper-flexion^{4,5}.

In some patients with IAE, lengthening of the external iliac artery can be shown. Schep has suggested that lengthening and kinking alone may be sufficient to cause flow reduction and symptoms during exercise, even in the absence of established endofibrotic change to the vessel wall⁶. However, while it may be a contributory factor in some individuals, kinking does not seem to be the principal cause of clinically significant flow limitation, since operative correction of kinking only provides relief of symptoms in around 50% of patients. It is the authors' personal opinion that in many patients it is primarily a reduction in compliance due to fibrosis of the external iliac artery that leads to a reduction in lower limb blood flow, rather than kinking or luminal obstruction per se.

CLINICAL FEATURES

Patients who suffer from IAE typically present with cramp in the calf, thigh or buttock that only occurs under significant training loads when tissue oxygen demand (and need for muscle perfusion) is high. In more advanced cases the symptoms may develop with only minimal exertion. Symptoms are unilateral in more than 80% of cases and pain may coexist with swelling, numbness or weakness of the limb. These symptoms may often seem very non-specific and difficult to differentiate from

symptoms of neurological impingement. However, the disappearance of symptoms within 5 minutes of ceasing exercise and the involvement of more than three muscle areas in the affected limb seem to be particularly good indicators of a potential vascular cause of pain⁷.

Routine physical examination is frequently normal in patients with iliac endofibrosis. Indeed, it is perhaps the absence of overt physical signs (particularly in the lumbar spine or the limb itself) that should prompt investigation for a vascular cause. The one positive examination finding that may point towards a vascular cause, is the presence of an audible bruit on auscultation of the femoral artery while the hip is in extension, though this is by no means universal.

Despite the apparent difficulty of identifying IAE with routine history and examination, sensitivity can be significantly improved with the use of exercise testing. Resting ankle-brachial pressure index (ABPI) is usually normal in affected individuals, but when measured within 5 minutes of ceasing maximal exercise, ABPI is markedly reduced and can identify endofibrotic flow-limitation with a sensitivity and specificity of over 80%⁸. These findings give credence to the typical history of pain that resolves within 5 minutes of stopping exercise. For patients with unilateral symptoms, the difference between affected and unaffected limbs can also be assessed. During the first minute of recovery, a 'between-leg' difference in ABPI of more than 0.18 is highly suggestive of an arterial lesion⁹. It is important to exercise athletes until they experience maximal pain and to measure brachial and ankle systolic pressures very promptly on cessation of exercise – ideally within 1 minute. Athletes frequently become significantly hypertensive during exercise and ABPI is therefore more helpful than ankle pressure per se.

IMAGING

Imaging is an important part of establishing the presence of IAE. Doppler ultrasound is usually the first line investigation as it is non-invasive and readily available in most vascular centres. Doppler waveforms are usually normal at rest. However, peak systolic velocity

can increase, particularly when assessed during hip flexion or isometric psoas contraction¹⁰. Duplex ultrasonography also allows assessment of the structure of the artery including tortuosity, vessel length, intima-media thickness and the presence of intravascular lesions. However, the sensitivity of ultrasound is highly user-dependent (particularly in a condition as uncommon as IAE) and assessment of common iliac artery lesions can be difficult since it may be obscured by bowel gas.

Magnetic resonance angiography can also be useful in identifying more severe flow limitation within the iliac arteries. CT-angiography is also used in some centres, though it seems to offer little diagnostic advantage over the combination of MR-angiography and duplex ultrasonography and has the disadvantage of exposing the patient to radiation.

Intra-arterial digital subtraction angiography has the advantage that it allows measurement of a pressure gradient across any suspected intra-arterial lesion. As with the other assessments of flow, there may be no abnormality in affected vessels at rest, but a pressure gradient can be shown following intra-arterial administration of vasodilators. A localised pressure

gradient of more than 10 mmHg (following vasodilator administration) indicates that there is a haemodynamically significant lesion. Interestingly, when vasodilators are administered during angiography to simulate exercise, patients will often report onset of their presenting symptoms in the affected limb, further confirming the diagnosis. Some authors have also suggested that intravascular ultrasound may be able to identify endofibrotic lesions that are not apparent on digital subtraction angiography, although the evidence for this remains sparse¹².

In clinical practice, a combination of these imaging techniques is often necessary and the most appropriate protocol may vary depending on local availability of services and expertise. Importantly, while cross-sectional imaging can be helpful, particularly to exclude more proximal lesions, subtle early onset IAE may be difficult to detect. In the authors' experience, exercise tests and duplex are probably the most reliable modalities, though these are highly dependent on the familiarity of both clinicians and ultrasound technicians with the condition. Specialist assessment is therefore advised whenever the condition is suspected.



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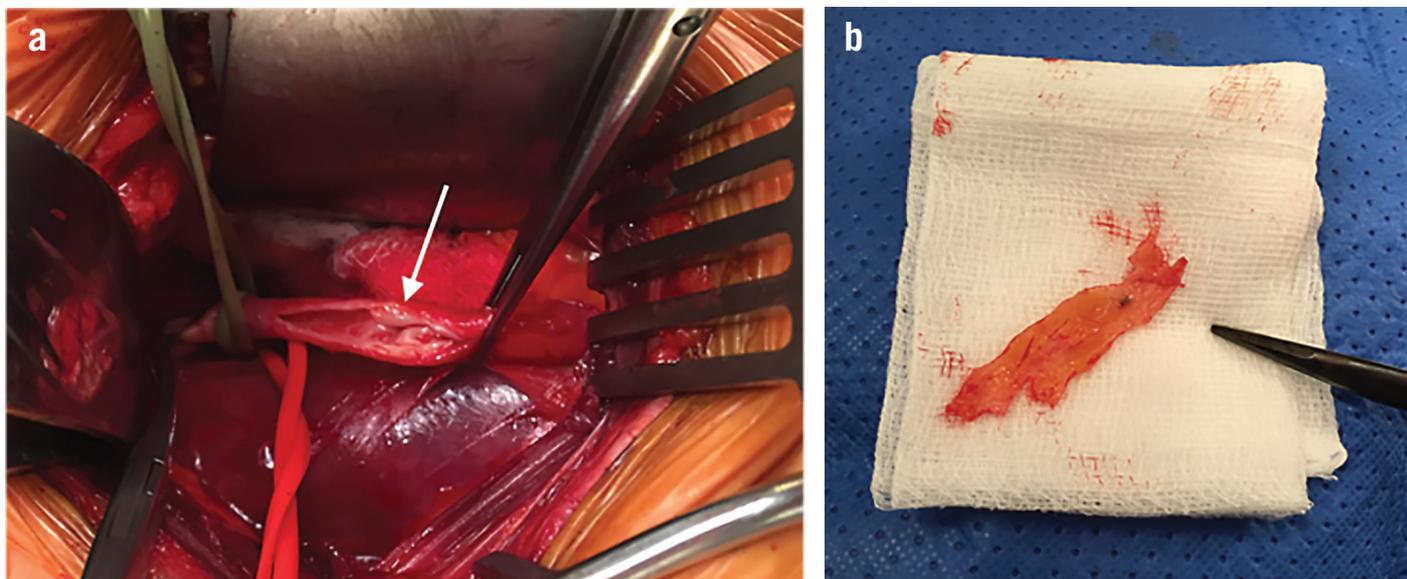


Figure 2: (a) Image taken during endarterectomy. Notice the area of endofibrotic intimal thickening (arrow). (b) Excised endofibrotic segment of intima.

MANAGEMENT

The natural history of IAE is poorly understood, but as with any medical condition, initial treatment should focus on non-operative strategies.

Whenever possible, patients should consider reducing the intensity of their training, changing to a sport that does not involve extreme hip flexion or stopping sport entirely. In some instances, athletes may gain symptomatic relief by adapting their technique to favour other muscle groups. For example, cyclists can move the saddle forward and raise the handlebars to minimise the degree of hip flexion. They can also try to avoid pulling up on the pedals in order to limit psoas hypertrophy. Unfortunately, these conservative measures are rarely helpful and in practice most patients find symptoms are progressive if they continue to train. Surgical intervention then becomes necessary if they wish to pursue their sport to the same level. Importantly, there have also been a number of reports of patients with IAE presenting with complete occlusion of the iliac artery and acute limb ischaemia. When this happens, it is believed to be secondary to dissection or thrombosis of the affected

artery and mandates immediate surgery to restore limb perfusion.

Patients with IAE are usually comparatively healthy, nevertheless atherosclerotic risk factors should be addressed where they exist, as there is some suggestion that the condition can predispose patients to the development of atherosclerotic disease later in life. The importance of smoking cessation should be emphasised and all patients should undergo screening for diabetes, hyperlipidaemia and hyperhomocysteinaemia, all of which are associated with premature atherosclerosis.

Angioplasty is ineffective in treating IAE. Despite some encouraging short-term results, almost all patients treated in this way have experienced recurrence of symptoms within a matter of weeks. Angioplasty may also result in a controlled dissection of the endofibrotic artery^{12,13}. Similarly, endovascular stenting should be avoided, as the same forces that led to the development of IAE are likely to cause stent fracture or migrate, resulting in arterial occlusion. Surgical correction is therefore the mainstay of treatment for IAE.

The nature of the surgical intervention is determined by the structural abnormality

identified on imaging. In most cases the fibrotic segment itself is dealt with using a standard endarterectomy technique that involves opening the artery and removing the fibrotic tissue from within. The arteriotomy is then closed with a vein (or synthetic) patch to prevent subsequent stenosis of the vessel (Figure 2). When there is minimal intimal thickening it is not always possible to perform an endarterectomy and the artery is then simply patched to increase the diameter of the flow lumen. Endarterectomy and patching is usually undertaken through an open incision in the groin or inguinal region, although some highly-specialised centres are now performing the procedure laparoscopically to minimise recovery time¹⁴.

Where abnormal connective tissue or arterial branches have been demonstrated, these can also be divided or released. In some cases, where the external iliac artery is excessively long, the fibrotic segment may be completely excised before re-anastomosis of the healthy proximal and distal portions of the artery. However, excision of excess artery that is merely kinked rather than fibrosed often fails to improve symptoms. Some authors advocate

complete excision of the affected segment even when the artery is not elongated. In such cases, it is then necessary to use an interposition graft (which may again be venous or synthetic) to re-establish arterial continuity. While this technique certainly ensures complete clearance of the affected segment, the authors feel it also has an undesirable impact on the structural integrity of the vessel – something that is intuitively uncomfortable in an area that is clearly under significant mechanical stress.

There is also some debate about whether intraoperative division of the inguinal ligament is advantageous. Theoretically, this could minimise ongoing compressive injury to the artery where it passes beneath the ligament. However, there is no clear evidence for this, particularly as prophylactic release on the asymptomatic side of affected individuals does not always preclude development of symptoms on that side¹⁵.

Little is known about the long-term prognosis for patients with IAE. While some who are treated conservatively may find their symptoms improve if they stop intense exercise, it is unclear whether the arterial lesion resolves or worsens in these patients. Similarly, those patients who continue to exercise without surgery are likely to have worsening symptoms, but it is unclear how many develop arterial occlusion.

There is also relatively little data available for the long-term outcome of those who are treated surgically. In the largest published cohort, Chevalier et al presented basic follow-up data for over 300 symptomatic patients that had undergone surgery for IAE, the majority of whom were treated with iliac endarterectomy¹³. The mean delay before returning to sport was 2.8 months and 99% had returned to sport at some level within the mean follow-up period of 53 months, suggesting broad success of the intervention. More recently, Schep et al presented their results from 24 athletes, 23 of whom were treated with surgical release of tethering arterial branches and connective tissue. No surgical reconstruction of the vessel was undertaken. Fifty-two percent of patients were symptom-free after intervention, but 48% did experience recurrence of symptoms to varying degrees, suggesting the effect of arterial tethering

and kinking may be additive to that of endofibrosis itself, but that arterial release is not sufficient to correct flow limitation⁷. It is the authors' opinion that isolated arterial release should therefore be avoided.

Despite the potential advantages, operative intervention should not be undertaken lightly as serious complications can occasionally occur. There has been at least one high-profile death related to surgery for IAE¹⁶ and the risks of limb ischaemia and limb loss also exist. More commonly, there is the risk to the femoral nerve and vein, as well as the bowel and ureter when the procedure is performed laparoscopically. While uncommon, restenosis of the treated artery has also been reported in a small proportion of patients.

Postoperatively, patients typically stay in hospital for 3 to 4 days to ensure they are mobilising freely before discharge. The discomfort associated with simple movement usually resolves within 4 weeks of discharge and patients are advised to refrain from training until at least 6 weeks after surgery. They are also prescribed 75 mg aspirin once a day for 3 months to reduce the chance of thrombosis in the operated artery.

Long-term outcomes remain unclear, however it is evident that surgery allows the majority of patients to return to sporting activity and broad estimates suggest around 80% can expect to be free of symptoms after intervention. Of the 20% who do have recurrence of pain, most are able to return to full activity, but with similar or slightly

improved symptoms. Further research is undoubtedly required in this field and it may be that the time has come to consider screening elite athletes – particularly cyclists – for IAE. It should also be a priority to develop consensus guidelines on the diagnosis, management and reporting of the condition.

SUMMARY

Exertional leg pain is a common symptom in athletes. Endofibrosis is an increasingly recognised cause of these symptoms, especially in endurance athletes such as cyclists. A focused history and clinical examination may allow clinicians to identify up to 80% of individuals with flow limitation in the iliac artery. Patients should then be referred for specialist investigations in an experienced vascular centre, including provocative exercise testing and duplex ultrasonography coupled with measurement of ABPI and peak systolic velocity. When there is evidence of flow limitation, MR-angiography (or CT-angiography) and catheter angiography can be used to further characterise the anatomy. However, it should be remembered that these modalities can appear largely normal particularly at rest.

Surgical intervention should only be considered when there is evidence of diminished flow in the iliac artery and conservative measures have been unsuccessful. The most widely used surgical method is endarterectomy and patch-

KEY POINTS

1. *Typical history of cramping pain that resolves within 5 minutes of ceasing exercise*
2. *Post-exercise fall in ABPI >0.18 is indicative of arterial stenosis*
3. *Further imaging can often appear normal and patients should therefore undergo assessment in a specialist centre*
4. *Surgery is the mainstay of treatment, with endarterectomy and patch-plasty of the affected artery*
5. *Establishing consensus guidelines for the diagnosis, management and reporting of the condition should be a priority*



plasty of the affected arterial segment, though interposition grafting may also be undertaken in some instances. Endovascular techniques should be avoided, as should isolated arterial release.

Despite very favourable results from surgery, further data is undoubtedly needed to clarify the longer-term outcomes in those who have undergone intervention for IAE. Randomised trials of the different surgical techniques are not feasible due to the relatively small number of patients and case series therefore remain the main source of evidence¹⁷. However, work is currently in progress to establish an international registry of affected individuals so that we might better understand the natural history of IAE and the progress of patients after surgery.

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Robert J. Hinchliffe M.D., F.R.C.S.
Reader/Consultant in Vascular Surgery

George Peach M.B.Ch.B., M.R.C.S.
Clinical Research Fellow
St George's Vascular Institute
St George's University Hospitals NHS
Foundation Trust
London, UK

Contact: robert.hinchliffe@nhs.net