REVIEW

Iliac Artery Compression in Cyclists: Mechanisms, Diagnosis and Treatment

C.S. Lim*, M.S. Gohel, A.C. Shepherd, A.H. Davies

Imperial Vascular Unit, 4 North, Charing Cross Hospital, Imperial College, Fulham Palace Road, London W6 8RF, United Kingdom

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Abstract
Objectives: To review the mechanisms, diagnosis and treatment options for symptomatic iliac artery compression in cyclists.
Methods: Pubmed, Medline, Embase and Google were searched using combinations of the terms 'iliac artery disease', 'iliac artery compression', 'iliac artery stenosis', 'cyclists' and 'athletes'.
Results: Tethering of the iliac artery by the psoas arterial branch and fibrous tissue, and muscular hypertrophy predispose the vessel to kinking and compression during cycling. Symptoms may only be present on maximal exercise in the cycling position. Provocative exercise tests using a cycling ergometer with ankle brachial pressure index measuring has a sensitivity of 85% to detect arterial insufficiency. Magnetic resonance imaging is increasingly being used as the investigation of choice to confirm the diagnosis, although digital subtraction angiography and colour duplex ultrasonography may also help. Conservative measures including adjustments to the cycling posture and bicycle setup should be recommended to all patients. The evidence for surgical and endovascular treatments is limited and the use of prosthetic graft should be avoided.
Conclusions: Iliac artery compression should be recognised as an important differential diagnosis in competitive cyclist presenting with lower limb symptoms. Although the optimal treatment strategy remains unclear, early diagnosis may reduce unnecessary investigations, and enable the cyclist to make appropriate adjustments and decisions in treatment management.

* Corresponding author. Tel.: +44 (0) 20 8846 7335; fax: +44 (0) 20 8846 7362.
E-mail address: cslim@doctors.org.uk (C.S. Lim).

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Introduction

Iliac artery compression in athletes was first described in 19841 and the majority of patients are competitive cyclists (90%),2 although similar disease in runners,3–4 cross-country
skiers, rugby players, footballers and body builders have also been reported. As competitive cyclists usually have a high level of fitness, diseases of musculoskeletal, neurological or general deterioration in performance are usually considered before arterial insufficiency. Consequently, the mean delay to diagnosis of iliac artery compression/endofibrosis in competitive cyclists is 2 years from initial presentation. It is likely that many patients have been forced to give up competitive cycling, without a diagnosis.

Methods

We searched Pubmed, Medline, Embase and Google using combinations of the search terms 'iliac artery disease' or 'iliac artery compression' or 'iliac artery stenosis' and 'cyclists' or 'athletes'. To increase our search results, we then searched the Google using the phrases ''iliac artery disease'' cyclists, ''iliac artery disease'' athletes, ''iliac artery compression'' cyclists, ''iliac artery compression'' athletes, ''iliac artery stenosis'' cyclists, and ''iliac artery stenosis'' athletes. Articles and webpages that had no mention of iliac artery compression syndrome in athletes were excluded.

Results

A total of 24 articles were found using Pubmed, Medline and Embase. All of them were reviewed. A further search in Google identified 99 webpages, of which 65 mentioned iliac artery compression syndrome in athletes and assessed.

How Common is Iliac Artery Compression in Cyclists?

Although the true prevalence of iliac artery compression secondary to cycling is unknown, vascular insufficiency may account for up to 10–20% of leg symptoms in top-level competitive cyclists. There were more cases reported in men than women. Patients usually present at a much younger age (average of 25 years; range 16–42 years) than those with atherosclerosis. It has been reported that of those who developed the problem, 15% were professional, 48% top amateur, and 28% recreational cyclists. The reported level of cycling is 8000–35,000 km per year or about 150,000 km in a lifetime. The external iliac artery is most commonly involved (90%), although multiple segments of the artery may be diseased in about 10% of cases. The condition is bilateral in around 15%, but there seems to be a left iliac artery predominance. Rarely, patients may also present with associated dissection of the iliac artery.

What Are the Mechanisms Contributing to Iliac Artery Compression in Cyclists?

Numerous anatomical, mechanical and postural factors are likely to contribute to the development of iliac artery disease (Figs. 1 and 2). Recurrent exposure to these factors (from repetitive competitive cycling), inflammatory and remodelling processes in the artery are thought to result in a stenotic intravascular lesion, known as endofibrosis. Specific contributory factors may be:

Posture

The aerodynamic posture that involves hip hyperflexion is characteristic in competitive cyclists and it has been estimated that this movement may be repeated up to 8 million times a year. Repetitive hyperflexion of the hip causes bending and stretching of the external iliac artery, which may damage the arterial wall, most commonly seen at its greater curvature.

Anatomical predisposition and kinking of artery

The longitudinal elasticity and excess length of the iliac artery are usually able to compensate for stretching and
movement during normal activity. However, fixation of the iliac artery may tether the vessel, causing kinking of the vessel during hip flexion. Such kinking has been observed in 70% of the cyclists operated for arterial insufficiency. Most commonly such tethering is caused by a psoas side branch of the iliac artery (52–60%) and fibrous fixation of the iliac bifurcation (78%), although about 9% were of unknown origin. Tethering may also occur at the circumflex iliac, epigastric and pudendal branches. Excessive vessel length and tortuosity may also predispose the artery to kinking during hip hyperflexion. Kinking of the artery alone may cause flow limitation in cyclists, but secondary endofibrotic damage may further exacerbate symptoms. In one study that used colour Doppler to assess 50 endurance athletes (46 cyclists) with 54 symptomatic legs and 16 asymptomatic cyclists (28 reference legs) as controls, significantly more symptomatic legs were found to have kinks and/or intravascular lesions in the external iliac artery than the asymptomatic legs when the hips were flexed. Furthermore, the presence of kinks and/or intravascular lesions in the external iliac artery seemed to be associated with higher peak systolic velocities.

Muscular hypertrophy

Competitive cyclists develop muscular hypertrophy from intensive training. Hypertrophied hip flexors (especially the psoas muscles) and abdominal muscles (such as external oblique) may compress the iliac artery. Muscular hypertrophy may also cause chronic stretching and lengthening of the iliac artery, hence predisposing it to kinking.

Endofibrosis

Endofibrosis refers to a stenotic endovascular lesion as a result of mechanical stress. It usually causes an isolated narrowing of 10–20% in the iliac artery. Histologically, endofibrosis is a different entity compared to atherosclerosis and fibromuscular dysplasia. It is characterised by intimal hyperplasia set in a moderately loose cellular connective tissue with variable amounts of elastin and collagen. Immunostaining demonstrated smooth muscle cells proliferation in the intima and adventitia. One study reported intimal fibroplasia occurs in 80% of the cases, while medial hypertrophy 60%, adventitial hyperplasia 80% and iliac artery thrombosis 40%. Other rarer morphological appearances which have been described include medial calcification and fibrosis. Affected artery segments were free from atherosclerosis. High blood flow through the iliac artery generated from increased cardiac output and systolic blood pressure during competitive cycling has been proposed as a potential contributory mechanism to vascular wall injury leading to endofibrosis. However, there is little evidence to support this.

How Does Iliac Artery Compression in Cyclists Present Clinically?

Cyclists with iliac artery compression may be asymptomatic at rest or during sub-maximal exercise. Features of arterial insufficiency may only be present at maximum exertion and/or during hip hyperflexion. Symptoms may include vague lower limb pain, cramp, numbness, weakness, claudication, unexplained deterioration of cycling performance and swelling. The lower limb pain often affects the thigh rather than the buttock and calf. On clinical examination, lower limb pulses are usually present with normal capillary refilling time. A bruit in the iliac fossa may be auscultated (44%).

What Investigations May Help in the Diagnosis of Iliac Artery Compression in Cyclists?

A combination of provocative exercise tests and vascular imaging, along with a high index of clinical suspicion, is usually required. Conventional investigation techniques may

Figure 2  Iliac artery during upright and hip hyperflexion. Dark arrow demonstrated acute angle of the iliac artery during hip hyperflexion when cycling.
need to be modified to mimic the posture of competitive cycling and/or to produce maximum exertion.

**Provocative exercise test and ankle brachial pressure index (ABPI)**

The resting and conventional post-exercise ABPI of these patients are usually normal. Therefore, specific cycle-ergometer-based protocols rather than standard treadmill exercises are more appropriate. It has been reported that the ABPI of pre- and post-maximal exercise on an ergometer would detect abnormalities in the arterial flow in about 85% of the cases. In the first minute post-maximal exercise, ABPI drops of 0.50 (sensitivity of 80–85%; specificity not reported) and 0.66 (sensitivity of 90% and specificity of 87%) have been suggested. Other measurement and technical modifications such as ABPI to heart ratio and simultaneous automated pressure measurements of all the limbs have also been studied, although the validity of such methods is yet to be proven.

**Imaging**

Imaging for iliac artery disease is challenging as intravascular lesions in cyclists are often much smaller than those of atherosclerosis and may be dismissed as insignificant. Many conventional imaging tools only produce two-dimensional pictures. Endofibrotic lesions may not lie in the visualised plane and could be overlooked as they are often situated eccentrically in the vessel. During conventional imaging, the posture of the patient is often very different to competitive cycling. Therefore, some abnormalities including kinking or compression of the iliac artery that may only occur during hip hyperflexion may be missed.

**Digital subtraction angiography (DSA)**

During angiography, an iliac artery lesion may appear as a beaded or smooth stenotic lesion usually starting just distal to the common iliac bifurcation and extending for about 5–6 cm down the external iliac artery. Calcification is uncommon. Direct comparison with the contralateral limb is essential as stenotic lesions may be subtle. During angiography the intravascular pressure gradient can also be measured. At rest, this is likely to be normal but a gradient may become detectable across the affected segment after pharmacologically induced distal vasodilatation such as using papaverine. One study of 13 patients of highly trained athletes (10 cyclists) reported that DSA (with hip flexion and extension) had sensitivities of 53.8%, 57.1% and 57.1% and specificities of 0%, 100%, and 100% for the detection of external iliac artery stenosis, the presence of a psoas artery branch, and long external iliac artery, respectively. In this study the sensitivity of DSA in diagnosing common iliac artery stenosis was only 12.5% (specificity of 100%). In another study, when all the examinations were performed in a “racing” hyperflexed posture, DSA demonstrated abnormalities in 100% of the cases.

**Magnetic resonance angiography (MRA)**

MRA is increasingly being used as the investigation of choice to diagnose iliac artery compression following a positive provocative test. MRA may have a higher sensitivity than DSA. There are numerous potential advantages of MRA including:

- Non-invasive and able to reconstruct three-dimensional images
- MRA allows the patient to flex the hip and may detect kinking in the iliac arteries
- Iliac artery length during hip flexion and extension may be measured
- MRA is able to assess arterial wall thickening

The length of the common and external iliac artery can be accurately measured with MRA to identify excessively long vessels. Since the height of an individual influences the length of the iliac artery, the ratio of the actual length of the iliac artery to the straight line distance between the starting and the endpoint of the artery has been used to identify excessively long iliac arteries. However, further studies are needed to validate such measurements.

**Ultrasonography and colour Doppler**

Ultrasonography was reported to have a sensitivity of 84.6% for the detection of external iliac artery stenosis but only 12.5% (specificity of 66.7%) for common iliac artery disease. Ultrasound findings with endofibrosis may include hyperechoic segmental myointimal thickening in the axial view, but changes are often subtle. It has been reported that ultrasonography has a sensitivity of about 85% in detecting endofibrosis. Ultrasonography has also been reported to have a sensitivity of 85.7% and specificity of 57.1% in detecting excessively long external iliac artery. Waveforms and velocity studies can detect flow limitations, but they are usually normal unless the patients are exercised to the maximum and/or in hip hyperflexion. Intravascular ultrasonography may also be used during angiography to demonstrate the degree and distribution of intimal thickening, when the measurement of pressure gradient is inconclusive.

**Treatment Options**

The treatment of iliac artery disease in cyclists is challenging as there are few studies and long-term outcome data are lacking. Furthermore, these patients are usually highly competitive athletes and may expect a return to their maximal level of fitness after treatment.

**Conservative management**

Conservative management comprising of risk modifications, cycling adjustments and lifestyle changes, should be instigated with or without other therapy. Although atherosclerosis is not the cause of the problem, reduction of cardiovascular risk factors should be considered in all cases. These include the smoking cessation, assessment for hyperhomocysteinaemia and consideration of anti-platelet and cholesterol lowering drugs. Cycling adjustments including modifying cycling posture and bicycle setup, reducing the level of exercise and even stopping cycling.
altogether should be considered when formulating a management plan. Patients should be advised strongly that conservative management is the safest treatment option while surgical and endovascular interventions are best avoided. A great challenge in the management of such patients is that most professional cyclists and many competitive amateurs may not be prepared to accept conservative treatment alone.8,45,52

Surgery

Various types of surgical intervention for iliac artery compression have been described in the literature. Surgery has often been portrayed as an alternative treatment option to conservative management despite the limited evidence based to support this approach.8,45,53 The type of the operation described depended on the pathological cause of the flow limitation including iliac artery kinking, the presence of a long and tortuous artery, extrinsic compression of the vessel, endofibrosis or a combination of these processes.8,10,21,30,52–55 Some of the previously reported procedures are described in Table 1. Minimally invasive procedures such as laparoscopic mobilisation of the external iliac artery or resection of fibrotic tissue have also been suggested.35

Of all the surgical procedures, the literature only provides support for iliac arterial release. A prospective study of 23 athletic patients (22 involved in some form of competitive cycling) who underwent surgical arterial release has demonstrated that iliac artery release is safe with no reported complications. The mean hospital stay was only 3 days. Following a median follow-up of 6 months (range: 4–36 months), 12 (52%) patients were asymptomatic and 11 (48%) patients still had some residual symptoms. In the latter group, 8 (35%) patients managed to resume competition at a pre-symptom level, but 3 (13%) did not. Overall significant improvement in ABPI and systolic velocities was also present.9

Overall, the evidence for surgery in iliac artery compression syndrome in cyclists is limited and thus should be avoided if possible. The use of prosthetic patches and grafts in these patients should be avoided due to the potential risks of infection and false aneurysm formation due to repetitive straining from excessive movement.35,52 These risks were highlighted in the recent case of a South African professional cyclist, who died at the age of 28 due to bleeding from an infected prosthetic graft previously inserted for iliac artery endofibrosis.51,52

Endovascular treatment

Endovascular therapy is less invasive than surgical treatment, which may result in earlier return to training and cycling and less muscle damage.35 However, balloon angioplasty may only provide short-term durability and symptom relief. Early recoil may occur due to the asymmetrical intimal thickening and elasticity of endofibrosis, which is different from atherosclerosis.35,45 Although repetitive balloon angioplasty for symptomatic recurrence may help,10 the effectiveness and acceptability of such an approach regimen remain unknown. There is also the potential risk of intimal dissection following balloon angioplasty due to the loose attachment between the endofibrotic lesion and the media at the internal elastic lamina.10,56,57 Cutting balloon angioplasty may offer some advantages but further assessment of this technique is still required.35 The use of endovascular stents must be avoided as repeated mechanical compression may risk the stent to disintegrate and fracture which may damage the iliac artery.10 Furthermore, the use of stents also raises the concern of accelerated neo-intimal hyperplasia at the stent edges due to mechanical compression and high turbulence flow during cycling.10

| Table 1 Commonly described surgical treatments for iliac artery pathologies in cyclists. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Operation       | Arterial release | Shortening of   | Resection of    | Endarterectomy  |
| Description     |                  | the artery      | fibrotic section| with vein patch |
|                 |                  |                |                 | angioplasty     |
| Indication      |                  |                |                 |                 |
| Precautions     |                  |                |                 |                 |
| Breaching of    | No               | No             | Yes             | Vein patch     |
| arterial wall   | Involvement of   |                |                 |                 |
| integrity       | graft            |                |                 |                 |

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Conclusions

Iliac artery compression should be recognised as an important differential diagnosis in competitive cyclist presenting with lower limb symptoms. Although there is no consensus on optimal management, early diagnosis may reduce unnecessary investigations, and enable the cyclist to make appropriate adjustments and decisions in treatment management. The evidence for surgical and endovascular treatments is limited, and the use of prosthetic grafts and stents should be avoided. As a randomised controlled trial may not be possible due to the relatively low number of patients, other forms of study including international registry (such as the UK Joint Vascular Research Group online ‘Iliac Artery Compression Syndrome Registry’)10,58 and prospective observational studies may be helpful.

Conflict of Interest/Funding

None.

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References


