



The Cyclists' Alliance



Exercised Induced Arterial Endofibrosis

Educational resource for female professional cyclists on arterial flow restriction in one or both legs due to kinking and/or endofibrosis of their iliac arteries

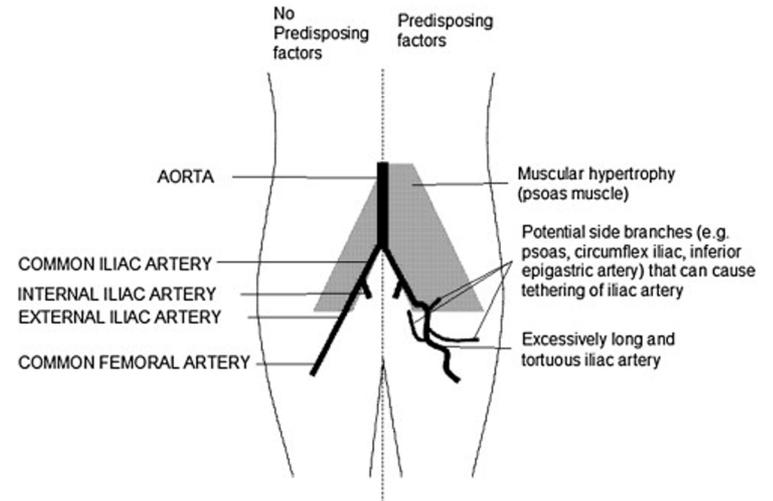
MORE THAN 20% OF PROFESSIONAL CYCLISTS DEVELOP COMPLAINTS DURING THEIR CAREER DUE TO A VASCULAR DISEASE OF THE PELVIC ARTERY.

MANY RIDERS MAY HAVE A VASCULAR PROBLEM, BUT NOT KNOW IT, AS THE CONDITION IS NOT WELL-KNOWN AND SYMPTOMS ARE OFTEN ASSOCIATED WITH THE NORMAL PHYSIOLOGICAL PROCESS OF EXHAUSTION DURING CYCLING.

IF THE CAUSE IS NOT FOUND AND DIAGNOSED, RIDERS THINK THEY LACK THE TALENT AND CONSIDER QUITTING, ENDING THEIR PROFESSIONAL CYCLING CAREER.

What is EIAE?

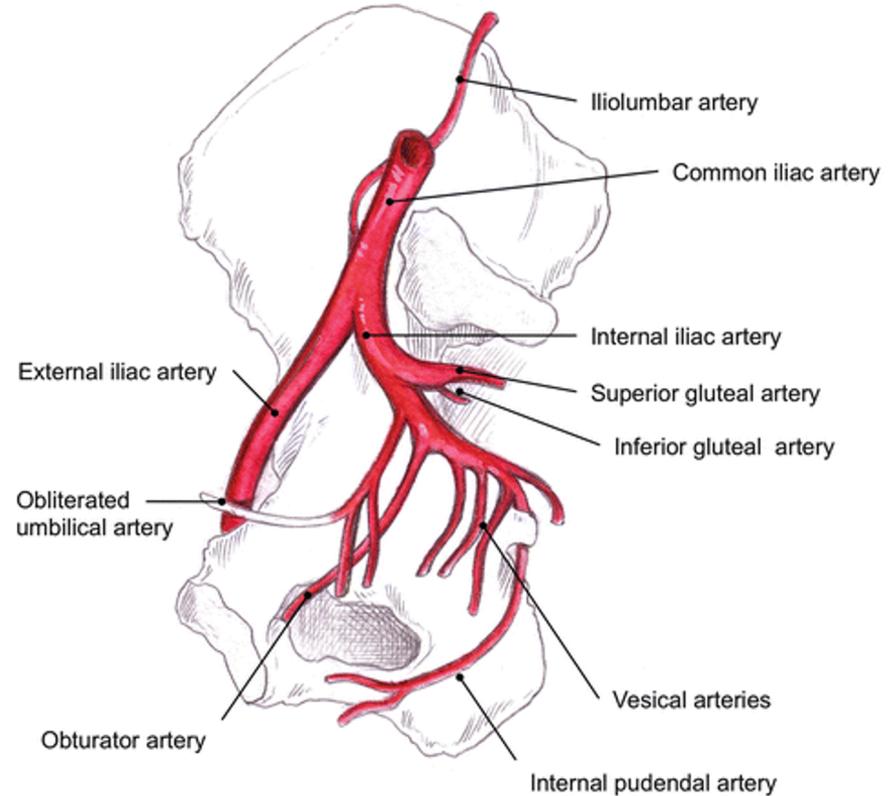
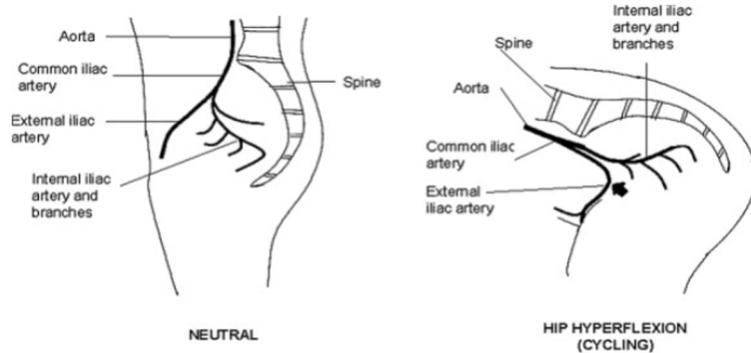
- ▶ EIAE manifests itself by causing pain referred to as “claudication” (a cramping sensation in the muscles) during maximal exertion whilst exercising.
- ▶ The cramping feeling is due to blood flow limitations in the iliac arteries which may have resulted from;
 - (1) endofibrosis
 - (2) functional obstruction from kinking,
 - (3) or a combination of both
- ▶ Possible multifactorial cause of exercised induced arterial endofibrosis include;
 - Extreme repetitive hip flexion in cycling position with very high blood flow demands triggers endofibrotic changes
 - Repetitive stretching of the iliac arteries can cause damage or kinking.
 - A build up of tough fibrous tissue on the inside of the damaged artery causing a narrowing and preventing optimal dilation during exercise.
 - Psoas hypertrophy. Enlarged / overused hip flexors and abdominal muscles (such as external obliques) from chronic high training load.
 - Muscle imbalances generating dysfunctional movement patterns and compressing the iliac artery
 - Excessive vessel length can predispose the artery to kinking
 - Fixation of the iliac artery to surrounding muscles may tether the vessel, causing kinking of the vessel during hip flexion.



Anatomical predisposing factors that may contribute to iliac artery compression syndrome during cycling

What is EIAE?

- ▶ Your pelvic artery supplies blood and thus oxygen to your leg muscles.
- ▶ Due to the bent position on the bicycle in combination with the many revolutions that your leg makes, the pelvic artery can make a 'kink'.
- ▶ Once kinked, the artery will kink at the same point with every strenuous effort. During heavy, strenuous exercise it causes problems in the blood supply.
- ▶ Over time, this can lead to damage to the artery



Iliac artery during upright and hip hyperflexion hip. Arrow demonstrated acute angle of the iliac artery during hip hyperflexion when cycling.

Dr Schep illustrates the 'kinking' effect with a garden hose

- ▶ *“As a professional cyclist you bend your hip about eight million times a year, whereby the blood vessel has to bend like a rubber band and meanwhile transport about ten liters of blood per minute. If the blood vessel is stuck just a little unhappily, it could buckle.”*
 - Dr. Goof Schep
- ▶ The diagnosis is frequently missed, as clinicians rarely consider a vascular condition in a young, otherwise healthy individual. To make matters more difficult, it is rare to find an abnormality on examination alone, especially in the early phase.
- ▶ Many athletes become frustrated as they undergo numerous investigations looking for alternative causes such as musculoskeletal and/or back problems



Goof Schep (r) samen met onderzoeker Martijn van Hooff

SYMPTOMS

How does EIAE present in female cyclists?

Symptoms of EIAE

▶ How do the symptoms present?

- Cramp / Ache / Heavy feeling
- Burning sensation
- Feeling of swelling
- Numbness and/or coldness
- Weakness and/or lack of power in affected leg(s)
 - an empty feeling

▶ Location of symptoms?

- Complaint of symptoms in multiple muscle groups should raise suspicion of a vascular issue
- Glutes
- Hamstring / Back of Thigh
- Quads / Front of Thigh
- Calf / Lower Leg
- Foot
- The complaints can occur in two legs, but they are often more pronounced in one leg.

When do these symptoms occur?

- These symptoms are typically only felt at near-maximal exercise (or hip hyperflexion), and subside on decreasing the intensity or resting for approximately 5 minutes.
- Athlete may be asymptomatic at rest or during sub-maximal exercise
- If you then try again to ride with intensity, everything will repeat itself and the complaints will be noticeable again after some time.
- Cyclists, therefore experience an inability to sustain maximal exertion on the bike
- Over the years, the complaints have become increasingly apparent and worsened.
- Unexplained deterioration of cycling performance
- Complaints may vary considerably from ride to ride.

Pro & Elite Cyclists explain their initial symptoms pre-diagnosis:

- ▶ *“4 years inexplicable feeling of lack of oxygen to my muscles. Both legs equally. Lacked power in seat. Got sick a lot. Couldn’t produce power in races to stay with front group then once dropped recovered enough to be able to go super hard again – and repeat. Some good days among all the bad days. No pattern. Eventually at worst; complete numbness of lower legs and feet. Severe ache and pain at rest off bike especially sitting at table”*
 - Sarah Roy, Australian cyclist for Team BikeExchange
- ▶ *“Burning feeling, weakness and difficult recovery in my left leg”*
 - Elena Cecchini, Italian cyclist for Team SDWorx
- ▶ *“Initially severe pain in my left quad. Over time it worsened to a cramping calf, sciatica-type pain and a numb foot alongside the quad pain. A loss of power too especially when riding on the drops/hoods/TT position”*
 - Alice Cobb, British cyclist
- ▶ *“Lots of pain in my left leg, as if your leg is being tied off. Performance decline, slower recovery. Oblique position in pelvis and back. Colder left leg and foot”*
 - Ann-Sophie Duyck, Belgian cyclist
- ▶ *“I’ve had both sides repaired. Right side started in my calf with running and felt like it would blow up. Both sides also felt like a vice squeezing my quad so hard causing pain and numbness. Both increase pain with hard efforts, especially climbing and cold”*
 - Jess Cerra, American cyclist
- ▶ *“Foot numbness, a blood pressure cuff sensation on my calf that got tighter and tighter, tingling, burning up in my glute and cramping of overused muscles that didn’t rely on blood supply from the iliac e.g. hamstrings”*
 - Emma Grant, British cyclist for Massi Tactic
- ▶ *“It started with a burning sensation in my left hamstring whilst doing a ZWIFT race, about 15mins in. The next time I did a race the cramping and burning moved to my Quadricep. When riding outside I couldn’t put the power down and hit my usual numbers, it felt weak. After an ITT, my leg throbbed continually for two straight days and I struggled to sleep. Further on I experienced cold and tingling sensation around the groin area”*
 - Lexi Brown, British Cyclist
- ▶ *“Some cramp in left leg and overall loss of power. And then a sudden experience of severe symptoms including extreme lactic acid on even light exercise, aching leg, cold numb foot”*
 - Charlotte Colclough, British Cyclist

SELF-CHECK

The self check consists of a number of simple questions. This determines the chance that a blood vessel problem is the cause of your complaints.

A simple tool to determine whether complaints are a vascular problem

- ▶ Dr Goof Schep, Sports Doctor at Máxima MC in the Netherlands has created the 'Self-Check' tool with a grant from ZonMw and in collaboration with:

- Sportgeneeskunde Netherlands
- KNSB (Skating NL National Federation)
- KNWU (Cycling NL National Federation)
- NTFU cycling association

- ▶ The self check consists of a number of simple questions (examples below) to determine whether the blood vessel/artery is the cause of your complaints.

- ▶ how many years, weeks, hours per week have/do you cycled on average in your life?
- ▶ Complaints only start above a certain speed, and / or above a certain power, and / or above a certain heart rate ?
- ▶ Are the complaints more pronounced in one leg?
- ▶ Your complaints have (almost) disappeared within 5 minutes of rest?

- ▶ Only available in Dutch

- ▶ <https://www.mmc.nl/sportgeneeskunde/selfcheck/>

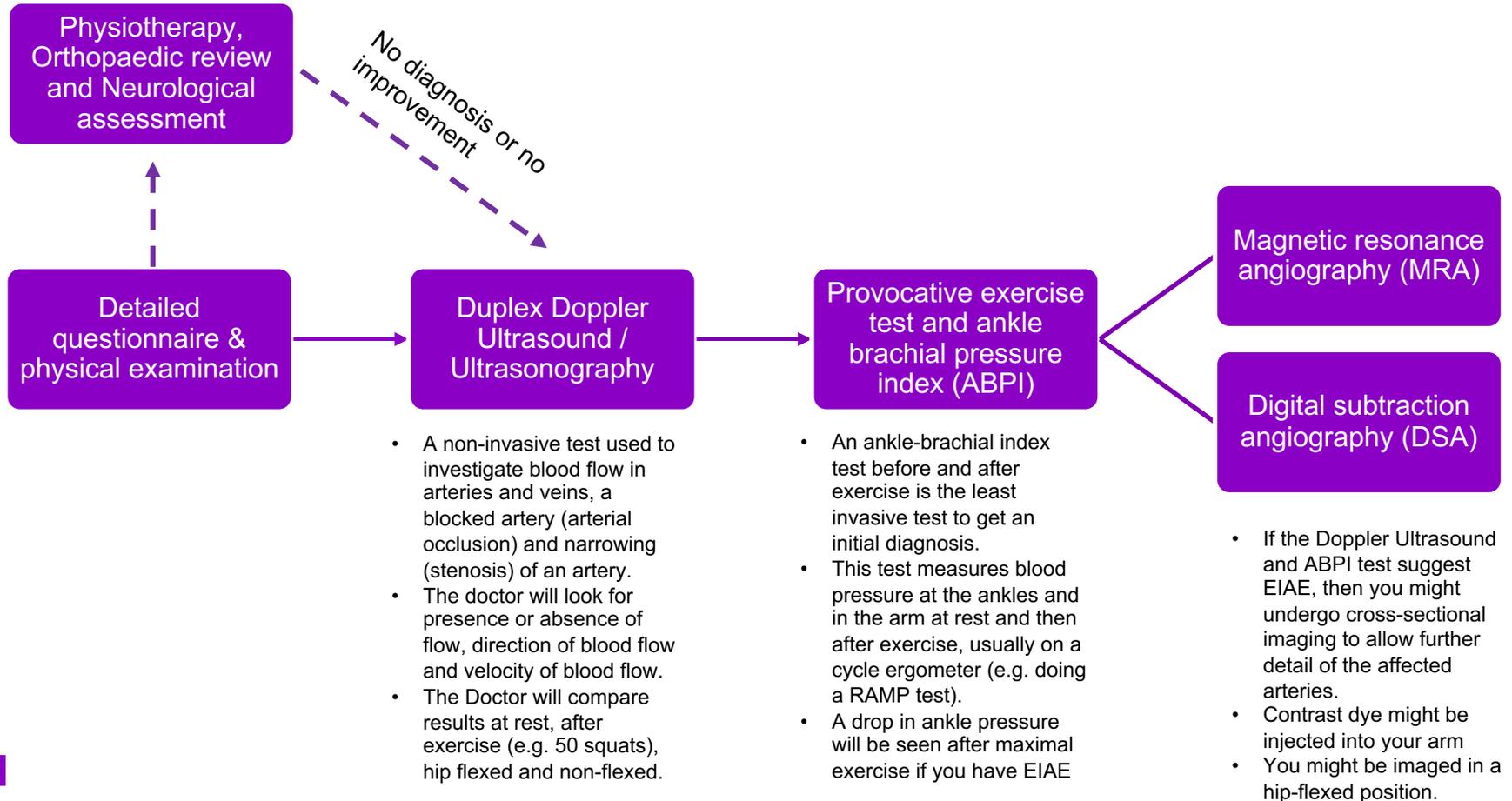
Deze self-check is ontwikkeld in afstemming met:



DIAGNOSIS

Testing options and requirements to diagnose EIAE or rule it out

Testing requirements for correct Diagnosis



Patient options if diagnosed with EIAE

Stop Cycling

- Losing your sport that has potentially defined you for so long can be a process of mourning. Similar to when professional athletes retire and lose their athlete identity, you may need help from a sport psychologist to transition away from cycling if you choose this option.
- Your EIAE may also prevent you from doing other vigorous sports, so discuss with your Doctor if there are other sports you could transition to or whether your diagnosis stops you from also practising other sports and exercise requiring a complete lifestyle change.

Continue Cycling

- Risk of worsening the endofibrosis, restricting the blood flow in that artery further
- Understanding your new reality that your leg(s) will only be able to tolerate a certain exertion, more rest & recovery for the muscles will be needed and most likely your total volume/intensity of cycling will decrease.
- Dealing with the emotional and mental anguish of not being able to cycle to your previous standard and needing to adapt your training & riding.

Surgical Intervention

- Each case presents differently, with numerous surgical options to correct the issue. And it's important to note that though the surgery has become somewhat routine for elite athletes, it isn't without its risks.
- *"I would only suggest an operation in those people whose symptoms are clearly progressing or if they are professional or an elite amateur who needs it because it's their living,"* Doctor Hinchliffe says. *"Most of the people I tend to say, 'Look, the only known treatment for this is surgery, but surgery comes at some risk. We don't know in the long term what the risks may be and it may require further surgery, and surgery on arteries is potentially limb- and life-threatening. If anything goes wrong, if you get an infection, then that's a big, big deal.'*

Source: [VeloNews](#)

TREATMENT

Discover the different options to manage and/or treat EIAE

Bike Fit

- ▶ If you don't opt for surgical intervention and your Doctor says it's OK to continue riding, it is important to change bike or alter the position on your bike to open the hip flexion angle.
- ▶ Pre-surgery and post-surgery in the recovery phase it is also worth considering changing bike or altering your position to open the hip angle.
- ▶ Edward Green - Science2Sport Ergo Fit
 - Raise the saddle to increase the hip flexion angle but not so high that it creates instability.
 - Raise the handlebars as much as possible and also consider a shorter stem.
 - As you get back to full fitness, gradually return to your normal position over time (rather than in one go)
- ▶ Andrew Pruitt, EdD, Sports Medicine Consultant, Clinically Retired
 - "The rider's post op position usually includes a slightly wider stance and a more upright torso position to avoid mechanical closure of the artery. Saddle choice is crucial post surgery as well. If you are prone to atherosclerosis (artery clogging) then you might be more prone to re-occurrence even with a perfect surgical reconstruction of the area"



Edward Green carrying out an [ErgoFit](#) at [Rocacorba Cycling](#), Spain.

Physiotherapy Timeline

Pre-Surgery - Physio

- Check for muscle imbalances around the pelvis.
- Deep core activation patterns and spinal/pelvis stability as well as the muscle length/tension relationship of the hip flexors and hip extensors.
- Correcting these imbalances early may prevent worsening of symptoms and possibly reduce the loading on the artery enough to prevent surgery.

Post-Surgery – Scar Tissue

- Once the scar is closed (approx. 2 weeks) & stitches have been removed, self massage the scar with cream (*vitamin E, Bio-oil, rose-hip oil*) twice a day for 5 minutes.
- Gentle circular movements over the scar, moving the skin in all directions so that the skin doesn't stick to the muscles underneath.
- Move the hip 15 times, 3 per day. Stand up, bend knee slightly off the floor and rotate leg outwards and back.

Post-Surgery - Physio

- Twice a week for 3-4 weeks when healthy enough to see a physio.
- Common issues seen in post-op EIAE female athletes include muscular imbalances of the hip, poor core activation and timing, overuse of bracing strategies of the diaphragm and obliques, overuse and tightness of TFL, psoas, rectus femoris. Underactivity of glutes and deep hip stabilizing muscles. Scar tissue tightness and impingement of the hip are common, this presents as groin or lower abdomen or thigh pain. Knee pain often presents due to reflexive/protective tightness of the hip muscles following surgery

Physiotherapy

- ▶ Retraining of the correct patterns of spinal and pelvis muscles is an important part of the prevention and rehabilitation process. This can prevent or reduce the symptoms of two of the possible causes of EIAE, namely Psoas hypertrophy and muscle imbalances.
- ▶ Regardless of pre or post surgery, **check if the deep core muscles** (pelvic floor muscles, transverse abdominus, diaphragm and multifidius) **are working properly**.
 - If these muscles are not being used with either correct timing or not working with enough strength to stabilize the pelvis and spine, other muscles like the psoas can become hypertrophic and potentially place increased stress on the artery.
- ▶ Next, **check the glutes**, as these contribute to the stability of the pelvis when high force is applied.
- ▶ Check for muscle imbalances, which develop when one part of the body is being used more than the opposite muscle group. This is described as agonists and antagonists.
 - the body will keep using the stronger muscle more, as it's easier for the body to choose the path of least resistance; over time this develops more and more strength in just one area. This can happen in the hip flexors (psoas, rectus femoris, TFL) becoming dominant over the glutes.



Source: Information provided by Kat Stene, founder of [Força13](#) & physio to Bike Exchange (A specialist in the hip & spine)

Stretching

- ▶ Stretching or massaging the dominant / overactive muscles is important to reduce the tension in these muscles.
- ▶ This will temporarily reduce the ability of the muscles to work at a high level and gives a window of opportunity for the antagonists to build strength.
- ▶ Stretching the psoas and rectus femoris is best done with the 'couch stretch'. Releasing the TFL is best done in sidelying and using a triggerball or trigger point massage technique (dry needling is very effective here).
- ▶ Just stretching the overactive muscles isn't enough as they will continue to work next time, so building the strength of the counter muscles over time (minimum 6 weeks) to be able to counteract and then be used as a primary force generator is essential.
- ▶ It's important to use only the correct muscles when you do 'glute' exercises as it's very easy for the body to cheat and use the stronger patterns (as it's easier).
- ▶ Getting feedback on the level of exercise you should be at and correct technique is very valuable.
- ▶ Building strength in the deep hip muscles that keep the femoral head back in the socket (quadratus femoris and gluteus minimus) as well as the prime hip abductors (gluteus medius and maximus) are key. Any glute exercise can work, as long as the 'overactive' hip flexors don't also come on at the same time.



Couch Stretch

Surgical Intervention

- ▶ **Everyone’s diagnosis is individual and presents differently. It is important you discuss the different surgical options that are relevant to your diagnosis.**
- ▶ Discuss the different surgical options available to you and the percentage chance that your surgeon has had successful surgeries where the patient has been able to return to cycling; including high-level / professional competition.
 - How many times have they done this operation? How many female patients have they operated on? How many of those surgeries were successful? How many of those successful surgeries was the patient back to the same or better level of cycling?
- ▶ One of the most common methods of repair is called “endofibrosectomy with patch angioplasty.” If the damage within the artery is well contained, the artery will be clamped, then cut lengthwise; any fibrotic tissue will be removed and the artery freed from any adhesions to the surrounding muscle tissue. Surgeons will then sew in a patch, ideally harvested from the saphenous vein in the calf or groin of the patient (this is known as an autologous graft). The advantage of using the patient’s own vein is that it is very resistant to infection, less likely to have blood clots form on it, and less likely to cause an inflammatory reaction. The artery won’t ever dilate quite the same as a natural one, so it will be made wider than what is normal, effectively allowing it to be dilated all the time. If an autologous graft isn’t possible (for example, if the veins are scarred, diseased, or very small), surgeons will use a prosthetic patch, usually made of a polyester fabric called Dacron that is commonly used to make sailboat sails.
 - According to Doctor Hincliffe “angioplasty and stents are particularly bad ideas for treatment of IAE, since symptoms always recur quickly and stents break very easily and quickly”. (Most vascular surgeons recommend stents for elderly patients with narrowed arteries — they work well for that application — but not for endofibrosis.)

Medical Professionals utilised by the cyclists we researched*

▶ United Kingdom

- Professor Robert Hinchliffe (North Bristol NHS Trust, UK)
- Mr Andrew Weale (North Bristol NHS Trust, UK)
- Dr Adam Howard (Ramsay Oaks Hospital, Colchester University Hospital and Ipswich Hospital, UK)
- Mr Andrew Tambyraja (Royal Infirmary of Edinburgh as a Consultant Vascular Surgeon, Scotland)
- Mr Andrew McKinley, Belfast Royal Victoria Hospital, Northern Ireland

▶ Netherlands

- Dr. Mart Bender (vascular surgeon) together with Dr. Goof Schep (sports doctor) work as a team at Máxima MC in Eindhoven & Veldhoven, the Netherlands.

▶ Italy

- Dr. Gian Franco Veraldi in University Hospital of Verona, Department of Vascular Surgery

▶ USA

- Margaret C Tracci, MD (UVA, Charlottesville, VA)
- Peter B. H'Doubler, Jr., MD (Emory Saint Joseph's Hospital in Atlanta, GA)
- Dr. Kenneth J. Cherry, M.D. (Sentara Vascular Associates at Sentara Norfolk General Hospital in Norfolk, VA USA)
- Dr. Michael Lee, M.D. and Dr. Jason Lee (Stanford Healthcare, Bay Area, USA)
- Dr Phillip J. Church, M.D., (Seton hospital on 38th street in Austin, Texas)

▶ Canada

- Dr. Nathalie Gilbert (Hôpital Saint-François d'Assise, Quebec)
- Dr Prasad Jetty (The Ottawa Hospital, Ottawa, Ontario)

▶ Australia

- Dr Roger Bell Vascular surgeon. Victoria Australia
- Dr Rebecca Magee, Buderim Private Hospital, QLD, Australia
- Dr William Campbell (Epworth Hospital, Melbourne Australia)

POST-OPERATIVE

Hear from some cyclists on their personal experience

Charlotte Colclough, (British) Elite Cyclist in the UK

- ▶ After a gradual loss of power, with some cramping, followed by a sudden onset of severe symptoms (extreme burning and foot numbness), I was diagnosed with bilateral EIAE in Aug 2017 (with a fully occluded left external iliac artery)
- ▶ My first surgery was the creation of an arteriovenous fistula in my left arm (with the target outcome of enlarging the basilic vein diameter)
- ▶ I then underwent a full bypass surgery, removing the basilic vein from my left arm and using this to create an iliofemoral bypass in my left leg (5 hour operation)
- ▶ Very light-headed and struggled with fainting on standing at first. But able to do gentle walks after a few days, building up to longer walks over the first few weeks. After 3 months I was able to get back on my bike, very gently (HR below 130bpm) for quite a few weeks. A very gradual build up but returned to some racing at 6 months post surgery
- ▶ In Sept 2018, I had a bovine patch endarterectomy on my right external iliac artery with similar rehab to my bypass surgery, however I was able to resume gentle cycling after 6 weeks this time
- ▶ During rehab I made some bike adjustments with a move to shorter cranks, a more upright position, avoiding riding on the drops and the use of a dual sided power meter for monitoring any changes in output.
- ▶ I have some ongoing muscle imbalance issues but 2.5 years post surgery now and back to enjoying plenty of riding and racing symptom free.

Arteriovenous fistula



Incisions



Removal of basilic vein & healing process



Post right leg endarterectomy



Lexi Brown, (British) Elite Cyclist in the Netherlands

- ▶ I had two kinks released (artery freed from any adhesions to the surrounding muscle tissue) by Dr. Bender at Maxima MC, Eindhoven. Two incisions were required to reach both kinks, through my abdomen and my groin.
- ▶ I was given 3-4 days worth of painkillers; including Paracetamol, Naproxen, Tramadol.
- ▶ I had to do 20-30 hip mobility movements 3 times a day until I was back to walking around. I found this exhausting & just walking to the bathroom was enough in the first few days.
- ▶ I was allowed to shower after 2 days and carefully remove the butterfly stitches. My skin went extremely dry and after some intensive moisturizing this went away after a couple weeks.
- ▶ Occasionally I got light headed if I tried to stand too long, or walk a little too far – listen to your body!
- ▶ My surgeon encouraged me to walk more and soon I felt able to walk slow & steady. I only walked, keeping my HR under 110bpm for the first 6 weeks – by week 6 I could do 15,000 steps a day.
- ▶ I saw a physio twice a week from week 8 to 11 to improve my pelvic core stability, stretch my overactive hip flexors and engage my under active glutes.
- ▶ I changed my position on my MTB to open my hip angle and increased the duration of riding by 10 – 30% each week.
- ▶ After exercising, I often had fatigue and sensations in the muscles in my left leg and took the necessary recovery before exercising again.

Abdomen incision



Week 3



Sarah Roy, Australian Pro Cyclist

- ▶ Rode a fair bit pre-surgery to remain fit for a better recovery post-surgery.
- ▶ "They cut deeply into my abdomen and after some hours fixing my broken artery they decided it wasn't good enough so undid it all, cut some more artery out and took a vein from my leg to patch it back up. They also found some 'stuff' blocking another part of a separate artery that they cleaned out".
- ▶ Spent almost a week in hospital at Maxima MC, The Netherlands. All I did was walk to the cafeteria and back to bed.
- ▶ My routine for next 2 weeks was Coffee, Compex (to keep my muscles activated without raising my HR), walk 1.5km to cafe, walk back, Compex, rest.
- ▶ I flew back to Australia from Europe doing everything I could to avoid a DVT. I certainly wasn't very relaxed. I was prescribed thrombosis injections for each flight, up and walking every 2 hours, compression socks on, legs up, minimal hip flexion, aspirin and other meds. It was great to have the Compex on board, a few sessions per flight with some standing rehab exercises as well to avoid the artery settling in an unwanted position post op.
- ▶ 7 weeks post-surgery I had a spin on the trainer every day this week building from 15 minutes to 30. I average about 110 watts and sit up to reduce amount of time in flexion. I stopped whenever I feel pain.
- ▶ 8 weeks post surgery and I did 5 flat road rides up to 90 minutes after an intro week indoors.



FURTHER READING

Links to additional sources of information if you want to find out more

Watch this video from Dr Bell



What can you do for athletes with vascular problems?

- ▶ Dr Roger Bell, from North Western Vascular Department in Melbourne, Australia talks about '[Claudication in Elite Athletes](#)' and the different treatment options.
- ▶ Watch the video [here](#)

Further Reading: Medical Papers

- ▶ [Iliac Artery Flow Limitations in Endurance Athletes](#) (Andrew R. Getzin and Marc Richard Silberman)
- ▶ [Endofibrosis and Kinking of the Iliac Arteries in Athletes: A Systematic Review](#) (G. Peach, G. Schep, R. Palfreeman, J.D. Beard, M.M. Thompson, R.J. Hinchliffe)
- ▶ [Arterial endofibrosis in professional cyclists](#) (G.F. Veraldi, M. Macri, P. Criscenti, I. Scorsone, C.C. Zingaretti, M. Gnani, I. Mezzetto)
- ▶ [Mid-Term Results of External Iliac Artery Reconstruction in Avid Cyclists: Analysis of Twenty-five Patients](#) (AD. Politano, MC. Tracci, N Gupta, KD. Hagspiel, JF. Angle, KJ. Cherry)
- ▶ [Results of external iliac artery reconstruction in avid cyclists](#) (Presented at the 2011 Vascular Annual Meeting of the Society for Vascular Surgery, Chicago, Ill, June 16-18, 2011)
- ▶ [Ankle to brachial systolic pressure index at rest increases with age in asymptomatic physically active participants](#)
- ▶ [Endofibrosis of Iliac Arteries in High-Performance Athletes: Diagnostic Approach and Minimally Invasive Endovascular Treatment](#)
- ▶ [Ankle to brachial pressure index in normal subjects and trained cyclists with exercise-induced leg pain](#) (Taylor AJ, George KP)