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CASE STUDY

A new diagnostic approach to popliteal artery entrapment syndrome

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Abstract

A new method of diagnosing and defining functional popliteal artery entrapment syndrome is described. By combining ultrasonography and magnetic resonance imaging techniques with dynamic plantarflexion of the ankle against resistance, functional entrapment can be demonstrated and the location of the arterial occlusion identified. This combination of imaging modalities will also define muscular anatomy for guiding intervention such as surgery or Botox injection.

Introduction

Popliteal artery entrapment syndrome (PAES) is an uncommon cause of lower limb claudication,[1] most commonly affecting young athletes.[2] Untreated, PAES leads to popliteal artery damage, embolisation and limb ischaemia.[3–5].

PAES is currently diagnosed with a combination of clinical presentation, clinical findings and imaging studies including computed tomography (CT)/CT angiography, magnetic resonance imaging (MRI)/MR angiography (MRA) and Doppler ultrasonography (USS).[4,5] The diagnostic capability of traditional static imaging techniques performed is limited in this dynamic condition. Angiographic imaging with the calves contracted is often technically challenging, as many patients are unable to maintain full contraction of the calves or require multiple contractions of the calves to occlude their popliteal arteries. This paper presents a new approach for the diagnosis and definition of PAES using a combination of ultrasound and MRI protocols. The new technique will diagnose both anatomical and functional entrapment types[6,7] as well as define the anatomy sufficiently for treatment.[4,5]

Methods

Ultrasound

Ultrasound is used as an initial screening examination to assess for entrapment. The popliteal artery is interrogated from above the knee joint to bifurcation, using a linear 12 MHz or 9 MHz vascular transducer. The artery is imaged with the leg in the neutral position to assess for intimal changes, stenosis or aneurysm with B mode imaging as well as velocity and waveform criteria. Transverse imaging is preferred as longitudinal imaging of a moving artery is technically difficult and misalignment may result in over calling stenoses. Cine loop capture is routinely used to document dynamic entrapment.

Graded dynamic assessment is then performed using B mode and colour Doppler imaging. The ankle is actively plantar flexed without resistance and external compression of the artery is checked. The sonographer or assistant adds resistance to the plantar flexion with manual pressure on the sole of the foot.

Finally the patient is assessed in the erect position whilst plantar flexing by standing on toes. Repeated plantar flexion until the patient is symptomatic may be required to demonstrate the occlusion. Both leg pain and occlusion of the popliteal artery are required for a positive diagnosis of PAES.[8]

During all forms of provocation, the popliteal artery must be assessed from above the knee joint (common location for gastrocnemius muscle compression) to below the knee joint (common location for plantaris muscle compression). If anterior leg symptoms are described, the proximal segment of the anterior tibial artery should also be assessed.

If narrowing or occlusion is observed, the site is marked with a fiducial and MRI is performed.

MRI

The MRI protocol incorporates the following: (a) definition of the anatomy surrounding the popliteal artery; (b) dynamic assessment of the popliteal artery during dorsi and plantarflexion; and (c) visualisation of the popliteal artery using a contrast angiogram. MRI can be performed on 1.5 or 3 Tesla systems.

(a) T1 weighted axial (5 mm thickness, 1 mm gap, 320 × 320 matrix, 24 cm field of view, 32 slices) and coronal images (5 mm thickness, 1 mm gap, 320 × 320 matrix, 28 cm field of view, 20 slices) are acquired with the patient at rest to demonstrate the popliteal artery and surrounding structures.

(b) The patient is asked to dorsi- and plantar-flex at the ankle (attempting to reproduce their normal pain symptoms) whilst acquiring T2 weighted 2D steady state (Fiesta, True Fisp) images axially across the popliteal region (5 mm thick, 5 mm gap – 8 slices, 24 cm field of view, 192 × 288 matrix, TR 4.2 msec, TE 1.8 msec, BW 83 MHz). The steady-state sequence is performed for one minute as a multiphase technique with a temporal resolution of 1 slice per second. The patient must maximally exert pressure when performing the dorsi and plantar flexion exercises, otherwise occlusion will not occur.

(c) The patient is instructed to dorsi and plantar flex until they provoke the pain usually experienced. The patient holds the plantar flexed position while a contrast MRI angiogram is performed (coronal, 40 cm field of view, 2.2 mm thickness, 320 × 256 matrix and 36 slices).

Results

The following images in Figure 1 are taken from a young female patient with a clinical history suspicious for PAES. This 19-year-old female hockey player that presented with several years of exertional left calf pain that had deteriorated over the last 6 months. She complained of slow onset cramping pain in the left calf with exercise and intermittent numbness in the left foot. She reported slow onset of symptoms when exercising on a flat surface however, climbing stairs was provocative. The pain can resolve with rest or persist for several hours after exercise. There were no symptoms in the right leg. Clinically the compartments of the calf were soft with no crepitus. The hop test was negative for a stress fracture or shin splints.

USS is performed first, with resting, plantar flexion and plantar flexion against resistance images.

Permission was obtained from the patient for this publication.

Discussion

The combination of USS and MRI/MRA modalities facilitates diagnosis of PAES, as well as defines the functional and anatomical components of the occlusion. This demonstrates the location of the occlusion and contributing muscles. These images guide management, either with surgery[9] or, more recently, Botox injection.[5]

As PAES predominately occurs in young patients, the absence of a radiation dose with these modalities is an important benefit.

Ultrasound is inexpensive and readily available, and useful as a screening tool to confirm occlusion.

Ultrasound can be technically difficult, as structures move significantly during muscle contraction. Over-diagnosing occlusion is a risk due to movement of the artery being mistaken for occlusion.

Use of no resistance, some resistance (the operator's hand) and high resistance (the patient's body weight) provides a grading of severity of occlusion. Popliteal artery occlusion against no resistance is thought to be a more significant finding than occlusion against high resistance. Varying degrees of occlusion can also be visualised with ultrasound, from stenosis only to complete occlusion.

MRI complements USS as it is also safe and readily available, and provides improved soft tissue definition.

MRI can demonstrate a variety of findings including abnormal lateralised insertion of the medial head of gastrocnemius, medial displacement and occlusion of the

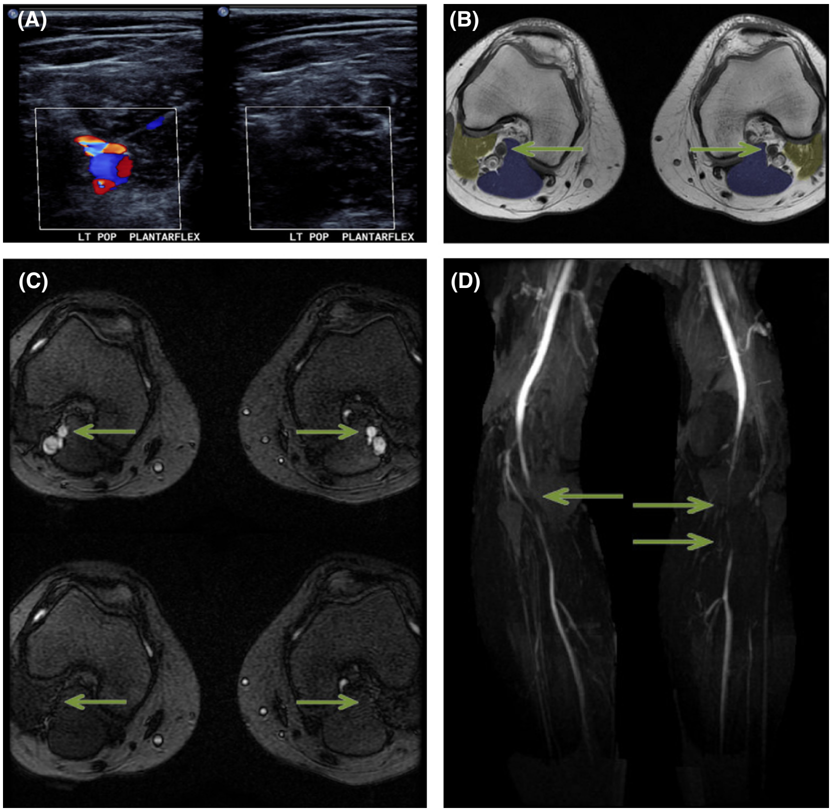

Figure 1. 19-year-old female with popliteal artery entrapment syndrome (PAES). (A) Two colour Doppler ultrasound images with a linear 12 MHz probe in the transverse position at the level of the knee crease with the patient prone. The image on the left demonstrates normal popliteal arterial and venous colour flow in the rest position. The image on the right taken in the same position with the foot in plantar flexion against no resistance, demonstrates complete obliteration of popliteal arterial and venous flow between the medial and lateral heads of gastrocnemeii. (B) Axial T1 magnetic resonance imaging (MRI) defining anatomy surrounding popliteal artery at the level of occlusion demonstrated on the previous ultrasound images. Medial head of gastrocnemius shown in blue, lateral head of gastrocnemius shown in yellow and popliteal artery (arrow). The medial head of gastrocnemeii are lateral displaced resulting in crowding of the popliteal fossae and lateral displacement of the popliteal arteries. (C) Axial T2 steady state MRI images at rest (superiorly) and with non-resisted plantar flexion (inferiorly) demonstrating occlusion of popliteal arteries bilaterally. Arrows indicate location of popliteal arteries. (D) 3D coronal maximum intensity projection (MIP) reconstruction of MR angiogram performed in plantar flexion. Occlusion visualised bilaterally by lateral and medial heads of gastrocnemius, and on left by the plantaris muscles. Arrows indicate locations of occlusions.

popliteal artery in the popliteal fossa, and fat tissue filling the normal location of the medial head of gastrocnemius.[10] It differentiates between anatomical and functional PAES, and accurately delineates muscles and anatomical boundaries. It is also more expensive and subject to motion artefact, which limits anatomical definition – partially relieved by using a steady-state sequence.

Further research is needed to determine whether occlusion of the popliteal artery above a particular threshold of plantar flexion force can more accurately diagnose function PAES.

Conflict of Interest

The authors declare no conflict of interest.

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