

# Popliteal Artery Entrapment Syndrome

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Popliteal artery entrapment syndrome (PAES) was described more than a hundred years ago in 1879 by T.P. Anderson Stuart as a cause of acute lower-extremity intermittent claudication. However, to this date, it remains underdiagnosed. Since it is primarily seen in young, active individuals, with minimal or no cardiovascular risk factors, the diagnosis becomes all the more challenging.<sup>1</sup> Having said that, it becomes imperative to have a high index of suspicion for this pathology in this patient population since the complications can be devastating, leading to long-term morbidity, with amputation being one of the most dreaded results.<sup>2</sup> PAES usually affects young, athletic men, presenting as intermittent claudication. It is primarily due to abnormal positioning of the popliteal artery in relation to the musculature of the popliteal fossa including the popliteus and gastrocnemius muscles, causing compression leading to vascular and neurogenic symptoms. Various classification systems were used to further the understanding of this entity. Currently, the most commonly employed one is the Popliteal Vascular Entrapment Forum classification, which has six different types, each describing a different anatomic variant as a cause for PAES.<sup>3</sup> However, PAES can broadly be divided into two groups, anatomical and functional. In the anatomical type, there is a clearly defined aberrant anatomical defect or malformation that leads to occlusion of the popliteal artery. In the functional subtype, although there is evidence of transient occlusion of the popliteal artery and subsequent intermittent claudication, no clear anatomic abnormality is noted that can explain the claudication.

In this issue of *Vascular Disease Management*, Mustapha et al published a series of four cases describing a varying range of presentations as well as management.<sup>4</sup> They further highlighted the importance of early recognition and timely intervention, which if delayed may lead to grave complications and outcomes. One critical aspect in diagnosing PAES is the presence of dynamic occlusion of popliteal vessels. However, this also is the more challenging aspect of PAES since dynamic occlusion can be seen on duplex ultrasound (US) imaging even in asymptomatic patients, with a prevalence ranging from 25%–80% based on various studies.<sup>5</sup> Therefore, careful history taking and focused physical examination become paramount. Although a validated clinical test for PAES has not been described, many physicians attempt to provoke symptoms by asking the patient to hop or perform plantar and dorsiflexion while standing on the edge of a step. Dorsalis pedis or posterior tibial pulses are palpated and popliteal fossa are auscultated before and after the maneuver to elicit any drop in the pulses. If patients do not develop any symptoms during or after this maneuver, then the likelihood of PAES may be low. However, development of symptoms or bruit on auscultation does not mean the patient has PAES as these may be patients with asymptomatic transient occlusion.

In these situations, non-invasive imaging modalities such as Doppler ultrasound (US) may provide additive diagnostic value.<sup>6</sup> Given the peripheral location of the popliteal artery, Doppler US makes for a relatively cheap, non-invasive option in this situation. It is the recommended first-line diagnostic modality for PAES. Provocative maneuvers such as sustained passive dorsiflexion and plantar flexion of the foot leading to loss of dorsalis pedis pulse or the posterior tibial pulse on Doppler US may be highly suggestive of PAES in the right clinical scenario. The occlusion can often resolve within 30 seconds of the provocative maneuver, making instantaneous assessment essential in accurate diagnosis and to avoid false negatives. The position of highest yield involves hyperextension of the knee with simultaneous active plantar flexion.

Traditionally, contrast arteriography has been the definitive test for diagnosis of PAES. Internal deviation, flatness, narrowing, or post-stenotic dilation are some of the signs on arteriography that raise suspicion for PAES. However, plain-film arteriography often leads to overestimation of the length of the stenosis due to dilution of the contrast material as it passes through the stenosis. This can be minimized with the use of digital subtraction angiography (DSA) since the image acquisition continues until there is no further filling of the artery, thereby enabling assessment of slow flow through any collaterals. Detection of collateral system is an important aspect of preoperative planning of severe PAES.

Other imaging modalities that assist in diagnosing PAES include computed tomography (CT) angiography and magnetic resonance imaging (MRI) angiography. CT trumps Doppler US in its ability to generate three-dimensional reconstructed images, which can be assessed from any angle to best visualize the popliteal artery in relation to its surrounding structures. Additionally, the value of CT imaging is even higher in situations of acute limb ischemia where the exact location of the stenosis is required prior to pursuing any intervention.<sup>7</sup> CT angiography trumps DSA with regard to detection of aberrant muscle in the popliteal fossa, relationship between the artery and surrounding structures, popliteal artery aneurysm, and cystic adventitial disease.

MRI angiography is another non-invasive imaging modality that is increasingly being used to detect PAES, especially in cases with an anatomic aberrancy.<sup>8</sup> It is useful in detecting abnormal insertion of the medial head of the gastrocnemius, medial displacement, level of occlusion of the popliteal artery, and differentiating intrinsic vascular disease from extrinsic compression. However, it falls short in the assessment of functional stenosis since it is challenging for the patient to maintain the provocative position of plantar flexion for the duration of the MRI. Recent studies have proposed the use of intravascular ultrasound (IVUS) to provide information on the exact location of the obstruction in addition to assessing the quality of the affected vessel wall, which may be important in

more advanced cases of PAES.<sup>9</sup> Given the limitations with each modality, it is prudent to use these tools in the appropriate clinical setting and use the findings in conjunction with each other, rather than exclusively.

In symptomatic patients, surgical intervention has been the longstanding treatment of choice in PAES in order to reestablish normal anatomy and vascular flow to the distal extremity.<sup>10</sup> In the anatomical variant of this condition, the progression of the occlusive disease is much more rapid, requiring urgent and invasive management. These patients may require exploration, fasciotomy, and myotomy of varying degrees. The stage at which the diagnosis is made becomes important in the surgical approach. Earlier diagnosis may limit the surgical intervention to mainly releasing the popliteal artery by division of the aberrant musculotendinous tissue. If the diagnosis is made at the stage of significant popliteal arterial stenosis or aneurysm, then complete vascular reconstruction of the popliteal artery may be required in addition to division of the aberrant musculotendinous structures. The progression of disease is much slower in function PAES, which allows for longitudinal follow-up in mildly symptomatic patients. Surgery may eventually be required if the symptoms recur more frequently or progress in severity. Unfortunately, surgical intervention has not proved to be as successful in functional PAES as in anatomical PAES, with only around 77% experiencing complete resolution of symptoms after surgery.<sup>5</sup> Recent focus has been on minimally invasive management options for PAES; one that has been gaining ground recently is the use of guided botulinum toxin injection. The proposed mechanism is to paralyze the culprit aberrant muscle responsible for the dynamic arterial obstruction in addition to possible smooth muscle relaxation of the popliteal artery leading to vasodilation. Wang et al recently published an innovative treatment of PEAS through an endovascular approach.<sup>11</sup>

A team approach toward management of this condition is essential, since diagnosis and surgical intervention require a high level of coordination between the physicians involved in the invasive and non-invasive diagnostic modalities, as well as the operating surgeons. An increasing number of cardiologists are currently performing peripheral interventional procedures. Sound understanding of PAES becomes imperative to prevent inadvertent percutaneous intervention of this condition with either angioplasty or stent placement. A high degree of suspicion for PAES is necessary on the part of cardiologists and vascular surgeons when faced with this clinical

scenario. Despite recent advancement in diagnostic modalities, surgical approach continues to be the procedure of choice when it comes to treatment of PAES. Although surgery can be curative, it comes with its own set of potential complications, such as postsurgical compartment syndrome. Further research is needed to evaluate other minimally invasive treatment modalities such as botulinum toxin injection therapy and endovascular treatment.

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