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Radiologic Demonstration of Popliteal Entrapment Syndrome with Surgical Correlation

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Abstract: Popliteal entrapment syndrome occurs when the popliteal artery is compressed due to the anomalous course of the popliteal artery and/or position of adjacent muscle. The popliteal artery normally enters the popliteal fossa by passing under the semimembranosus muscle, traveling obliquely through the fossa and exiting between the gastrocnemius heads. Variations in embryological development can result in an anomalous course of the popliteal artery and/or adjacent muscles in turn causing arterial compression. Popliteal entrapment syndrome is a rare entity with the incidence rate reported at 0.16%. As such, while there is a significant body of literature surrounding popliteal entrapment syndrome, given its rarity and differing definitions of the causative anatomical pathology, the quality of evidence is poor. This case highlights a unique pathognomonic finding of a wide separation of the popliteal artery and vein caused by an aberrant slip of the gastrocnemius muscle on ultrasound and MRI; a finding which should alert clinicians to the diagnosis of popliteal entrapment syndrome. Diagnosis of popliteal entrapment syndrome is typically made based on radiological and clinical findings. MRI allows for visualization of the anatomical variation underlying the entrapment. Recognition and correct diagnosis are particularly important for surgical planning, and preventing progression to thrombosis, embolization and/or aneurysmal degradation of the vessel.

Keywords: Vascular Surgery, Popliteal Entrapment Syndrome, Radiology, Case-Study

1. Introduction

Popliteal entrapment syndrome is a rare clinical entity in which the popliteal artery is compressed by adjacent muscle and tendinous structures [1-3]. Repeated microtrauma from compression causes damage to the internal elastic lamina and smooth muscle leading to fibrosis. This in turn predisposes the vessel to atherosclerosis and thrombosis formation [1-3]. The incidence of popliteal entrapment syndrome in cadaver specimens is as high as 3.5%, [1, 4] however, clinically significant entrapment is reported at a much lower rate of 0.16% [1, 5] among young men recruited for military service. However, the incidence of asymptomatic popliteal entrapment syndrome is estimated to be much higher at 56% [6].

The popliteal fossa is a diamond shaped depression on the posterior aspect of the knee joint. The tibial, common fibular, sural and posterior femoral cutaneous nerves, as well as the popliteal artery and vein and the short saphenous vein pass through this fossa [7]. The superomedial aspect of the popliteal fossa is bound by semitendinosus and semimembranosus muscles. The superolateral boarder is bound by the biceps femoris, while the inferior boarders are bound the medial and lateral heads of the gastrocnemius muscle. Normally the popliteal artery enters the fossa by passing under the semimembranosus muscle, traveling obliquely through the fossa, before exiting between the gastrocnemius heads [7].

Variations in embryological development can result in anomalous course of the popliteal artery and/or anomalous position of adjacent muscle, in turn causing compression. Anatomical variation resulting in entrapment is classified into types I – IV (table 1) [8-10]. While this classification system, proposed by Whelan and modified by Rich, is most commonly used there are several that exist [8, 9, 11]. Differing classification of the underlying pathology is a contributing

challenge to assessing the true prevalence of this etiology.

Table 1. *Whelan and Rich classification of popliteal entrapment syndrome.*

Type	Description
I	Due to aberrant course of the popliteal artery
II	Due to aberrant insertion of the medial head of the gastrocnemius muscle and medial deviation of the popliteal artery
III	Due to accessory slip of the medial head of the gastrocnemius muscle
IV	Due to popliteal artery coursing underneath the popliteus muscle
V	Any form of entrapment involving both the popliteal artery and vein
VI	Other variations

While there is a significant body of literature surrounding popliteal entrapment syndrome, given the rarity of this condition and differing definitions of anatomical pathology, the quality of evidence is poor. As such, we present the clinical and radiographic findings of a patient with popliteal entrapment syndrome. Notably, this case highlights the unique pathognomonic finding of a wide separation of the popliteal artery and vein on ultrasound (US); a finding which should alert clinicians to the diagnosis of popliteal entrapment syndrome. The patient consented to the use of details and images associated with this case.

2. Case Report

A 43-year-old male presented with right leg claudication, which appeared after walking 20-30 steps. He experienced numbness and coldness within the right foot. While the patient smokes a pack of cigarettes per day, he has no other cardiovascular risk factors such as high blood pressure, dyslipidemia or diabetes. The patient has a history of seizures, Crohn's disease, asthma and alcohol use disorder.

On physical exam, the patient had a right femoral pulse but no distal pulses on the right side. The patient's pulses on his left side were normal. His ankle brachial index on the right was 0.25 compared to a normal ankle brachial index of 1 on the left.

Ultrasound showed complete occlusion of the right popliteal artery (figure 1). A wide separation was noted between the right popliteal artery and right popliteal vein.

Magnetic resonance imaging (MRI) demonstrated complete occlusion of the distal superficial femoral and popliteal arteries with hyperintense T1 thrombus and intimal thickening (figure 2). The T1 images, axial and sagittal, demonstrated anomalous insertion of the medial head of the gastrocnemius between the popliteal artery and vein.

Angiography demonstrated a 10 cm occlusion of the popliteal artery (figure 3). Several small collaterals reconstituting the popliteal artery at the geniculate level were apparent. Below the knee the popliteal, proximal anterior tibial and tibioperoneal trunk were patent.

The preoperative diagnosis was popliteal artery occlusion secondary to popliteal entrapment syndrome. Therefore, a reversed saphenous vein bypass from the distal superficial femoral artery to the tibioperoneal trunk utilizing the right long saphenous vein with lysis of the accessory slip of the medial head of the gastrocnemius muscle was performed (figure 4). A posterior approach was utilized, resulting in normal pulses in the foot and normalized ankle-brachial index.

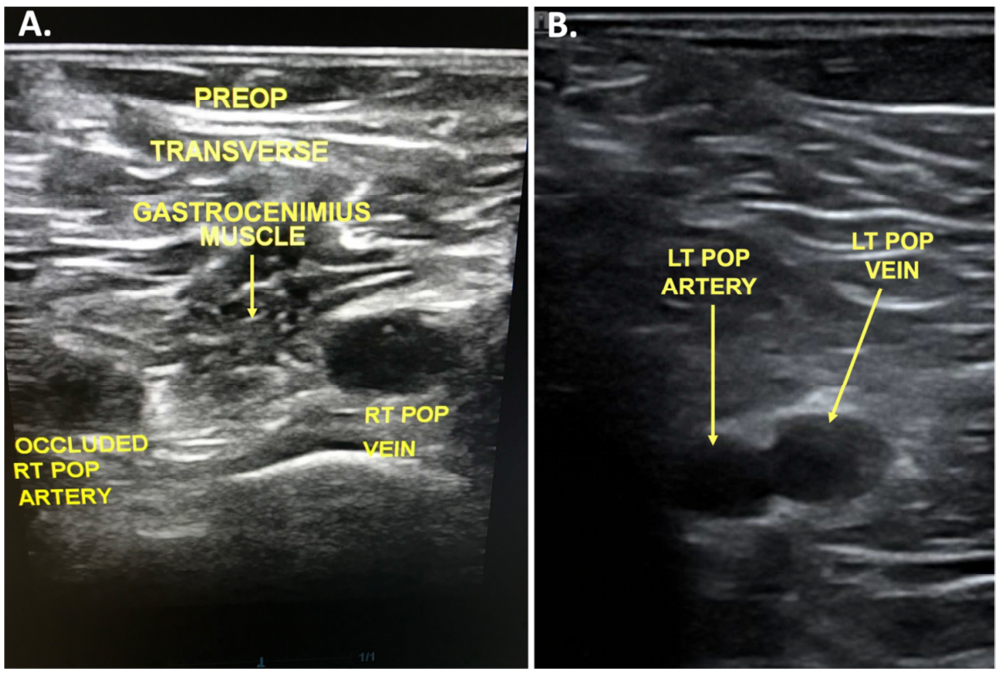

Figure 1. *(A) Axial ultrasound image demonstrating aberrant slip of the gastrocnemius muscle. (B) Normal for comparison.*

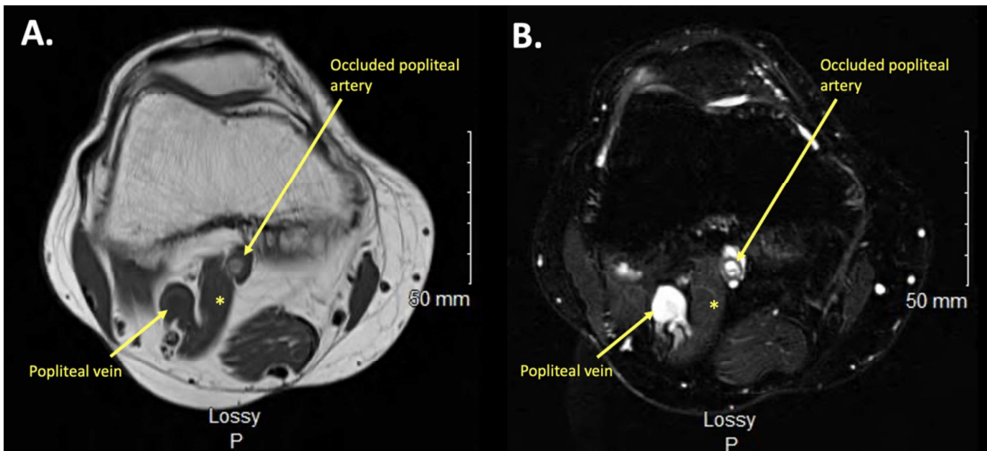

Figure 2. *(A) Axial T1 image. The asterix denotes the aberrant slip of medial head of the gastrocnemius muscle between the popliteal vein and occluded popliteal artery. (B) Axial post gadolinium image. The asterix denotes the aberrant slip of medial head of the gastrocnemius muscle between the popliteal vein and occluded popliteal artery.*

Figure 3. *(A) Angiogram in the arterial phase demonstrates occlusion of the popliteal artery. (B) delayed imaging demonstrates delayed opacification of the of the popliteal artery (arrow).*

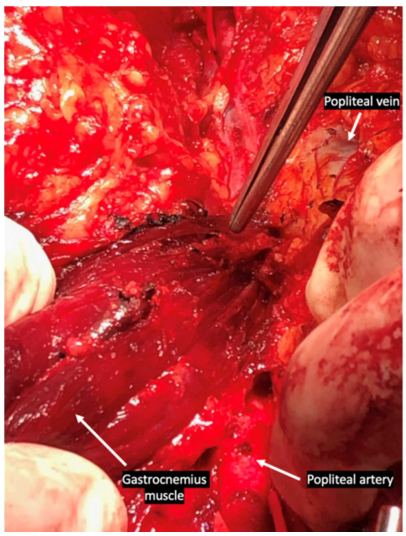

Figure 4. *Intraoperative image demonstrating the aberrant slip of the gastrocnemius muscle.*

3. Discussion

As demonstrated by our case and others, popliteal entrapment syndrome typically occurs in healthy males under 50 years old [1, 2, 12]. At diagnosis symptoms have usually progressed because of thrombosis, embolization and/or aneurysmal degeneration. Delayed diagnosis likely stems from a failure to consider a vascular etiology in the context of a patient with minimal cardiovascular risk factors, in addition to the rarity of popliteal entrapment syndrome [1, 2, 12].

On ultrasound, if occlusion is not present, compression of the popliteal artery can be provoked by plantar and dorsiflexion [6]. Doppler ultrasound is also useful to detect an increase in peak blood flow as the artery is compressed by these maneuvers. In our patient, disease had progressed to complete occlusion of the popliteal artery, which was visualized on ultrasound. Notably, our patient's ultrasound showed the wide separation of the popliteal artery and vein by the aberrant slip of the gastrocnemius muscle, a

pathognomonic finding suggestive of popliteal entrapment syndrome.

MRI allows for visualization of the anatomical variation underlying the entrapment. This is particularly helpful to guide surgical management. T1 weighted MR sequence is typically the most useful in understanding etiology behind the entrapment allowing for visualization of the anatomical location of the popliteal artery and surrounding muscles [2]. MRI can also be used to distinguish an intrinsic vascular etiology from extrinsic compression [2].

MRI is considered superior to angiography when evaluating popliteal entrapment syndrome, given that classical findings on angiography are not always present [13, 14]. Angiography classically shows medial deviation and resulting compression of the popliteal artery with plantar flexion. In a small study of 6 patients and 7 limbs, only 1 limb demonstrated this finding [13, 14]. Although MRI is the best diagnostic test, the anatomic variation can be overlooked, particularly when an occlusion is not present.

Diagnosis of popliteal entrapment syndrome is typically made on the basis of radiological and clinical findings [1-3]. Correct diagnosis is particularly important for surgical planning, and preventing progression to thrombosis, embolization and/or aneurysmal degradation of the vessel. Without appropriate intervention, there is a risk of ischemia and limb loss. Popliteal entrapment syndrome should be suspected in young individuals presenting with claudication, minimal cardiovascular risk factors and radiological evidence of wide separation of the popliteal vein and artery, and/or narrowing of the popliteal artery. The contralateral side should also be investigated, as it has been previously reported that popliteal entrapment syndrome is bilateral in 25-67% of patient [6, 15]. Given the progressive nature of popliteal entrapment syndrome, symptomatic patients with radiological evidence of popliteal entrapment syndrome should be treated surgically. Surgical intervention involves endarterectomy and vein patching or saphenous vein bypass plus division of the anomalous muscle or tendon [1-3].

4. Conclusion

In summary, this case demonstrates the pathognomonic finding of a wide separation of the popliteal artery and vein caused by an aberrant slip of the gastrocnemius muscle [1, 2, 12]. With most cases occurring in young healthy males, delayed diagnosis often results from a failure to consider a vascular etiology in the context of few cardiovascular risk factors, in addition to the rarity of popliteal entrapment syndrome. However, unfortunately, with delayed diagnosis, risk of ischemia and limb loss increases [1, 2, 12]. Diagnosis is made on based on both radiological and clinical findings. Ultrasound is useful to assess for occlusion, evaluate blood flow and in some cases, visualize anomalous location of adjacent muscles resulting in arterial compression. MRI is the best diagnostic test, being consider superior to even angiography, as it allows for visualization of anatomical variation underlying entrapment, which is helpful for surgical planning [13, 14].

Conflicts of Interest

The authors declare no conflict of interest.

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