CT and CTA Findings in Popliteal Artery Entrapment Syndrome

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Abstract

Background: Popliteal Artery Entrapment Syndrome (PAES) is an uncommon anomaly affecting young adults present with calf claudication. It is characterized by various anatomic relations between the muscle and arteries in the popliteal fossa, resulting in arterial compression.

Purpose: The aim of this study was to evaluate the role of CT and CT Angiography (CTA) in the diagnosis of PAES.

Material and Methods: Ten patients (12 legs) who underwent surgical treatment for PAES over a 7-years period were evaluated retrospectively. CT and CTA were performed on each affected limb.

Results: Characterization and classification based on CT and CTA were consistent with intraoperative results.

Conclusion: CT and CTA can show anatomic variations in the popliteal fossa and may be valuable in the diagnosis of PAES in adults presenting with intermittent claudication.

Key Words: CT – CTA – Popliteal – Artery – Entrapment syndrome.

Introduction

POPLITEAL Artery Entrapment Syndrome (PAES), despite its rarity, is the most common cause of surgically correctable lower-limb vascular insufficiency among young adults without background atherosclerosis [1].

Two distinct subtypes of PAES, (1) Anatomic and (2) Functional, have been identified [3]. The normal popliteal artery runs between the two heads of the gastrocnemius muscle in an oblique, mediatolateral orientation, superficial to the popliteus muscle. This normal relation is disturbed in anatomic PAES [3].

PAES occurs when the popliteal artery is compressed secondary to an abnormal relationship to the adjacent muscle and tendons. Compression of the popliteal artery due to the abnormal position of the adjacent structures may result in repetitive microtrauma and early atherosclerosis, leading to popliteal artery stenosis or occlusion [4].

PAES occurs bilaterally in 27-67% of patients. Several schemes have been described for classification of PAES. The most accepted classification system, proposed by Love and Whelanb [5] and modified by Rich and colleagues [6] (Table 1).

Accurate diagnosis of PAES is important. Imaging techniques are necessary to confirm the diagnosis. Digital Subtraction Angiography (DSA) has long been the primary imaging technique used to diagnose PAES. Non invasive techniques such as Doppler sonography, CTA, MRI, and MR Angiography (MRA) can be used in addition to DSA.

In this study, we evaluated the clinical application of CT and CTA in the diagnosis of PAES.

Table (1): Classification of Popliteal Artery Entrapment Syndrome [7].

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Medial head of gastrocnemius muscle is normal; popliteal artery is deviated medially and has an aberrant course.</td>
</tr>
<tr>
<td>II</td>
<td>Medial head of gastrocnemius muscle is located laterally; no deviation of popliteal artery.</td>
</tr>
<tr>
<td>III</td>
<td>Abnormal muscle bundle from medial head of gastrocnemius muscle surrounding the popliteal artery.</td>
</tr>
<tr>
<td>IV</td>
<td>Popliteal artery is located deeply and entrapped by the popliteus muscle or a fibrous band.</td>
</tr>
<tr>
<td>V</td>
<td>Popliteal vein is also entrapped with any type of popliteal artery.</td>
</tr>
<tr>
<td>VI</td>
<td>Popliteal artery is normally positioned and entrapped by a normally positioned, hypertrophied gastrocnemius muscle.</td>
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</table>

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Material and Methods

This study is a retrospective one. The CT and CTA of twelve lower limbs (ten patients) with surgically proven and CT documented popliteal artery entrapment at Mansoura University Hospital in the period from October 2007 to May 2014 were reviewed. The mean age was 41.7 years (range, 28 to 60 years). Nine of the study patient were male and one was a female. The clinical presentations were infrapopliteal claudication, rest pain and paraesthesia with symptoms worsening on exercise. The symptoms were bilateral in two of the ten patients. The duration of symptoms varied between 3 months to 5 years. No patient had any previous history of cardiovascular disease.

CTA was performed on a 16-MDCT scanner (Phillips Healthcare, Netherland). Patients were placed feet-first and supine on the couch of the scanner. The patient’s extremities were positioned with the knee and ankle joints in the neutral position. The scans extended from the aortoiliac superiorly to cover the lower extremity arteries down to the feet distally. The parameters were as follows: A section thickness of 3mm; gantry rotation time, 0.8 second; pitch, 1.375; X-ray tube voltage, 120kV; and the mean tube current, 250mA. Non-ionic high concentration contrast media was used and the dose was determined based on the patient weight (2mg-I/kg). Once the contrast bolus dose has been determined, injection into an antecubital vein via an 18-gauge needle at a flow rate of 3.0-4.0mL/s was done and followed by saline flush to clear the inflowing veins of contrast medium. The scanning delay was set by an automatic triggering system. Continuous low-dose fluoroscopy (120kV, 120mA) at the level of the lower abdominal aorta was initiated 10 seconds after the beginning of the contrast material injection. After reaching the preset enhancement level of 100HU, data acquisition was performed in a craniocaudal direction. Delayed images (90-second delay from the initial time of injection) were obtained in patients with poor cardiac output or slow distal runoff. Cross sectional images were reconstructed for both limbs on a workstation with a 1.25-mm slice thickness at 0.7-mm intervals. For each patient, Maximum Intensity Projection (MIP), Multiplanar Reconstruction (MPR), and Volume Rendering (VR) were used. The soft-tissue anatomy and vascular structures around the knee were assessed on the CT cross sectional images. For a more detailed analysis MIP, MPR, and VR were used to assess the arterial tree.

The CTAs were evaluated to determine the presence or absence of popliteal artery stenosis (more than 50% diameter reduction by visual estimation), occlusion, or aneurysm. Multisegmental disease or background changes of atherosclerosis were excluded in all patients. The extent of collateral circulation and filling of the distal vessels were assessed. Abnormalities in the course of the popliteal artery and femoral insertion of the gastrocnemius tendons, as well as aberrant muscle slips or fibrous bands compressing the artery, were specifically sought. Popliteal artery entrapments were classified according to modified Love-Wheelan’s classification (Table 1).

Fig. (1): 52-year-old male with popliteal artery entrapment syndrome of right lower extremity who presented with calf claudication. (A) Axial CT angiography image reveals lateral location of medial head of right gastrocnemius muscle (long arrow) and partial stenosis of popliteal artery consistent with type II anomaly, and caudal portion shows aneurysmal dilatation (B).

Results

In each patient, both popliteal arteries were well assessed. Abnormalities in the course of the artery and genicular collaterals were best demonstrated in coronal MIP and VR images. There was adequate demonstration of the soft-tissue structures in the popliteal fossa that enabled identification of the cause of entrapment in all limbs.
Patient demographics and CTA findings are shown in (Table 2). Popliteal artery entrapment was bilateral in two patients (20%), and unilateral in 8 patient (80%). Type I was diagnosed in 2 limbs, type II in 4 limbs Fig. (1), type III in 4 limbs and type IV in 2 limbs according to Whelan and Rich classification.

CTA images revealed stenosis of the popliteal artery in three limbs and occlusion in five limbs. Occlusion of the artery was total in three limbs Fig. (2) and partial in two limbs. Also aneurysm formation was revealed in four limbs of which three were partially thrombosed Fig. (3). Medial displacement of the popliteal artery noted in two limbs.

The axial CT images of soft tissue window were carefully evaluated and showed abnormal lateral insertion of the medial head of gastrocnemius muscle in four limbs, medial displacement of popliteal artery in two limbs and aberrant accessory slip of the medial head of gastrocnemius muscle in four limbs.

Hypertrophy of medial head of gastrocnemius muscle was noted in one limb of type II.

VR and MIP reconstruction showed good genicular collaterals supplying the distal popliteal arterial segments.

Three patients were evaluated by both CTA and DSA, there were no significant differences between the length of stenosis, occluded segments and collaterals identified on CTA compared with DSA findings. The abnormalities in the popliteal fossa seen at surgical exploration matched the information gained from CTA in all patients.

![Fig. (2): 52-year-old male with popliteal artery entrapment syndrome of right lower extremity who presented with calf claudication. (A) Axial CT angiography image reveals lateral location of medial head of right gastrocnemius muscle (arrow) and occlusion of popliteal artery consistent with type II anomaly, and caudal portion shows thrombosed popliteal artery (B). (C) MIP images shows occlusion of right popliteal artery and genicular collateral developments.](image-url)
Fig. (3): 60-year-old male with popliteal artery entrapment syndrome of right lower extremity who presented with calf claudication. (A) Axial CT angiography image reveals abnormal muscle bundle from medial head of gastrocnemius muscle (arrow) and short segment stenosis of popliteal artery consistent with type III anomaly, and caudal portion shows with partially thrombosed aneurysm (B). (C) MIP image shows the partially thrombosed aneurysm of right popliteal artery.

Table (2): Patient demographics, CTA findings and surgical procedure.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Patient Age</th>
<th>Sex</th>
<th>Affected limb(s)</th>
<th>Symptoms</th>
<th>Type on CT</th>
<th>CTA of popliteal artery</th>
<th>Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45</td>
<td>M</td>
<td>R</td>
<td>Intermittent claudication and mild edema in right leg.</td>
<td>II</td>
<td>Aneurysm formation.</td>
<td>Interposition graft.</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>M</td>
<td>R</td>
<td>Intermittent right calf claudication.</td>
<td>III</td>
<td>Partially thrombosed aneurysm.</td>
<td>Muscle release, interposition graft and aneurysmectomy.</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>M</td>
<td>R</td>
<td>Intermittent right calf claudication with coldness and numbness.</td>
<td>II</td>
<td>Short segment of popliteal artery partial occlusion by a thrombus.</td>
<td>Interposition graft.</td>
</tr>
<tr>
<td>4</td>
<td>52</td>
<td>M</td>
<td>R</td>
<td>Calf claudication.</td>
<td>II</td>
<td>Long segment of total occlusion.</td>
<td>Interposition graft.</td>
</tr>
<tr>
<td>5</td>
<td>42</td>
<td>M</td>
<td>Bilateral</td>
<td>Calf claudication at physical activity.</td>
<td>I</td>
<td>Medial displacement of PA on both sides.</td>
<td>Interposition graft.</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>M</td>
<td>Bilateral</td>
<td>Intermittent claudication.</td>
<td>III</td>
<td>Bilateral partially thrombosed aneurysm.</td>
<td>Interposition graft.</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>F</td>
<td>R</td>
<td>Rest pain, edema.</td>
<td>II</td>
<td>Long segment of total occlusion.</td>
<td>Interposition graft.</td>
</tr>
<tr>
<td>9</td>
<td>30</td>
<td>M</td>
<td>R</td>
<td>Calf swelling and pain.</td>
<td>IV</td>
<td>Short segment of stenosis 50%.</td>
<td>Surgical release.</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>M</td>
<td>R</td>
<td>Calf claudication.</td>
<td>IV</td>
<td>Total occlusion.</td>
<td>Surgical release.</td>
</tr>
</tbody>
</table>
Discussion

Popliteal entrapment's anatomical basis was first described by Anderson Stuart in 1879 [8]. Its clinical significant was realized in 1965 by Hamming and Vink [9]. In 1965, Love and Wheelan coined the term "popliteal artery entrapment syndrome" [5].

The arterial compression may cause chronic microtrauma with local premature arteriosclerosis and thrombus formation resulting in distal ischemia. In addition, stenosis and turbulent flow can lead to poststenotic ectasia or aneurysmal formation. PAES is a progressive condition so early diagnosis and early treatment may prevent many complications [10].

In our study PAES was bilateral in 20% of cases, frequency of bilateral involvement ranges from 30 to 60%, although values as high as 81% have been quoted [11]. Thus, it is essential to evaluate both limbs even if the clinical symptoms are restricted to a single limb, as the symptoms may be unilateral but with bilateral involvement [1].

The typical presentation is that of a young healthy adult man, in the 20 to 40 year age group, often athletic. There is a strong male predominance [1]. As seen in our study 90% of patient were male and the mean age was 41.4.

Although PAES is difficult to diagnose clinically, it must be considered in any young adult with no cardiovascular risk factors presenting with acute limb ischemia or intermittent claudication [12].

DSA was the reference standard for the diagnosis of PAES, but DSA cannot show the soft-tissue anatomy cannot identify the underlying cause. An occlusion or aneurysm of the popliteal artery due to PAES is difficult to be differentiated from arteriosclerotic or degenerative causes [5].

DSA may have a role in the evaluation of patients with claudication, but it can't diagnose PAES, especially in cases of arterial occlusion. DSA has been replaced by noninvasive techniques, such as Doppler sonography, CTA, MRI, and MRA [13].

CTA is a novel diagnostic tool for PAES, it can delineate muscles, vessels, fat and bone in the popliteal fossa and their relationship. Also, it provides axial images of the soft-tissue structures which lead to accurate grading of popliteal arterial stenosis or occlusions and evaluation of surrounding muscular anomalies. CTA can also be used for the evaluation of the contralateral limb to rule out bilateral entrapment [12].

Several postprocessing techniques, such as MPR, MIP, and VR, can be used to provide 3D reconstructions and describe vascular abnormalities. MPR is useful for the detection of arterial deviations and aberrant muscles. Lateral and oblique views of CT images can give information about the origin of aberrant muscles and the relationship between the popliteal artery and surrounding structures [12]. The detailed description is useful for clinicians to decide whether surgery is indicated [14].

MIP and VR images give sufficient 3D information about the popliteal artery. The segmental arterial occlusion and the degree of postocclusion refilling are shown by MIP and VR images accurately [8]. In our study, MIP and VR images provided excellent evaluation of vascular lumens.

MIP and VR images reconstructed from the volume data acquired during CTA can show internal deviation of the artery, flatness or clinched appearance, narrowing, mural irregularity, and segmental occlusion. Poststenotic dilatation and aneurysms have also been well demonstrated on CTA [15]. CTA is also useful in evaluating occluded arteries. Arterial occlusion is a common complication that may be seen in half of the limbs at presentation [16]. In our study complete occlusion of the popliteal artery with genicular collaterals, seen in 30% of the limbs. In all three patients with occluded popliteal artery, there was CTA evidence to diagnose PAES, as abnormal course of artery, localised single-segment involvement, and obvious abnormality in the anatomy of the popliteal fossa.

In contrast, catheter angiography has limited value when the artery is thrombosed, and it cannot differentiate occlusion from other causes. However, CTA can distinguish the occlusion found in PAES from other conditions, such as atherosclerosis, cystic adventitial disease, and popliteal mass. Also, an aneurysm beyond an occluded artery is better seen on CTA than Digital Subtraction Angiography (DSA) [15].

In this study the angiographic information obtained by CTA was adequate for surgical decision making. There was no discrepancy between the angiographic data obtained on CTA and at surgical exploration, confirming its adequacy as an effective modality for vascular assessment in PAES.

Small sample size, retrospective study and lack of direct correlation with catheter angiography or MRI are major limitations of this study, but the
high degree of concordance between surgical and CTA inferences endorses its clinical relevance in the management of PAES. This study also suffers from an inherent selection bias because only surgically proven cases were included. Again, the reviewers were not blinded to the clinical diagnosis.

In conclusion, CT and CTA is a novel and readily available imaging modality in the diagnosis, characterization and classification of PAES.

References


