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Duplication of the superficial femoral artery: comprehensive review of imaging literature and insight into embryology

Sachintha Hapugoda[1], Charlie Chia-Tsong Hsu[1], Gigi Nga Chi Kwan[1], Trevor William Watkins[1] and John A Rophael[2]

Abstract

An extremely rare case of duplicated superficial femoral artery (SFA) was incidentally observed on computed tomography angiogram (CTA) of the lower limbs for presurgical planning for an osteomyocutaneous fibula flap in a patient with T4a oropharyngeal squamous cell carcinoma (SCC). To our knowledge, this is the sixth reported case in the imaging literature. We performed a comprehensive review of the English literature and discuss the underlying embryological origin underpinning this rare anatomical variant.

Keywords

Femoral artery, anatomic variation, embryology, multidetector computed tomography, angiography

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Introduction

Variation of the lower limb arterial anatomy is rare and may pose clinical importance for surgical bypass or endovascular intervention. Anatomical variation of the femoral artery is rare and includes absent or duplication of the profunda femoris artery, persistent sciatic artery with associated aplasia or hypoplasia and rarely duplication of the superficial femoral artery (SFA) (1). In contrast, from the limited case reports of SFA duplication, about half of the cases were found on imaging for investigation of lower limb claudication while the remainder were discovered incidentally (2–6). Herein, we report an incidental finding of SFA duplication on lower limb computed tomography angiography (CTA) performed for presurgical planning of a fibula osteomyocutaneous flap. We discuss the clinical importance and embryologic basis for this rare anatomical variant.

Case report

A 65-year-old man with T4a oropharyngeal squamous cell carcinoma (SCC) underwent CTA of the lower limbs for presurgical planning of a fibula osteomyocutaneous flap. The patient did not complain of claudication symptoms; however, there was a history of significant vascular risk factors including a 20-pack/year smoking history, hypertension, and hypercholesterolemia. CTA of the lower limbs shows duplication of the left SFA into two vessels of equal luminal caliber (Fig. 1), 4 cm from its origin and extending over 20 cm before converging at the adductor canal to reform a single SFA (Fig. 1). The diameters of the duplicated SFAs were marginally smaller than the contralateral single SFA without significant atherosclerotic plaque disease. Post-processing three-dimensional volume rendered images better depict the anatomical orientation of the duplicated left SFA (Fig. 2). Aside from this incidental finding, the remaining lower limb arteries

[1]Department of Medical Imaging, Princess Alexandra Hospital, Brisbane, Australia
[2]Department of Surgery, St Vincent's Hospital, University of Melbourne, Fitzroy, Australia

Corresponding author:
Charlie Chia-Tsong Hsu, Department of Medical Imaging, Princess Alexandra Hospital, Brisbane, Australia.
Email: charlie.ct.hsu@gmail.com

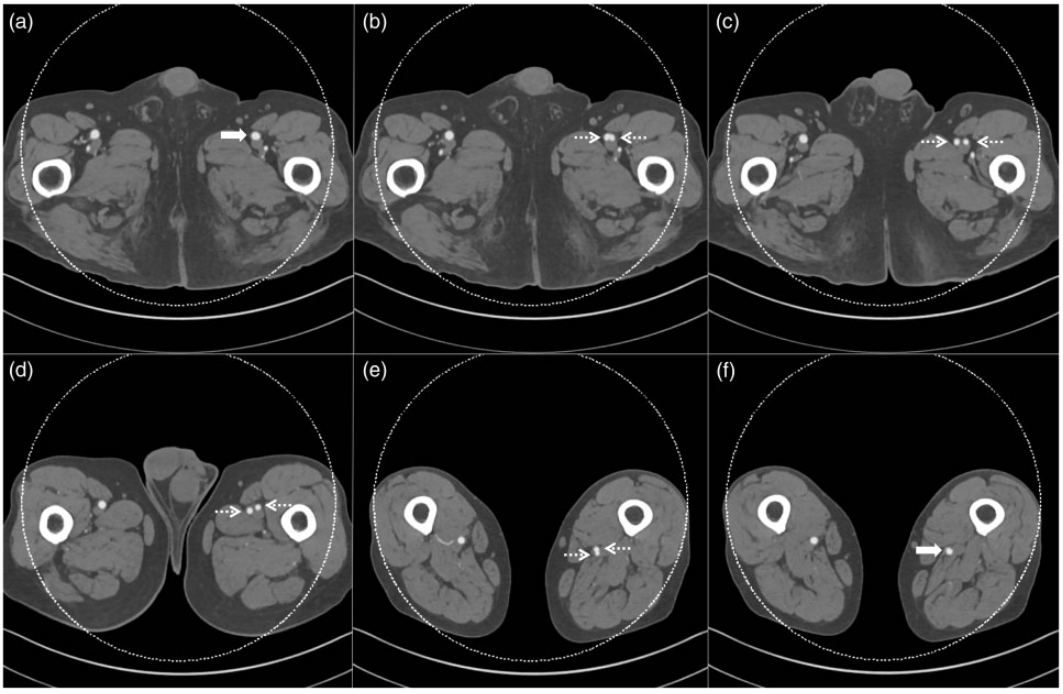

Fig. 1. CTA of the lower limbs in the axial plane demonstrates duplication of the left SFA (dotted arrows) approximately 4 cm inferior to the CFA bifurcation. The duplicated SFA appears symmetrical in caliber although individually the vessel lumens are marginally smaller in caliber than the contralateral single right SFA. The duplicated SFA fused at the entrance of the adductor canal to form a single lumen vessel.

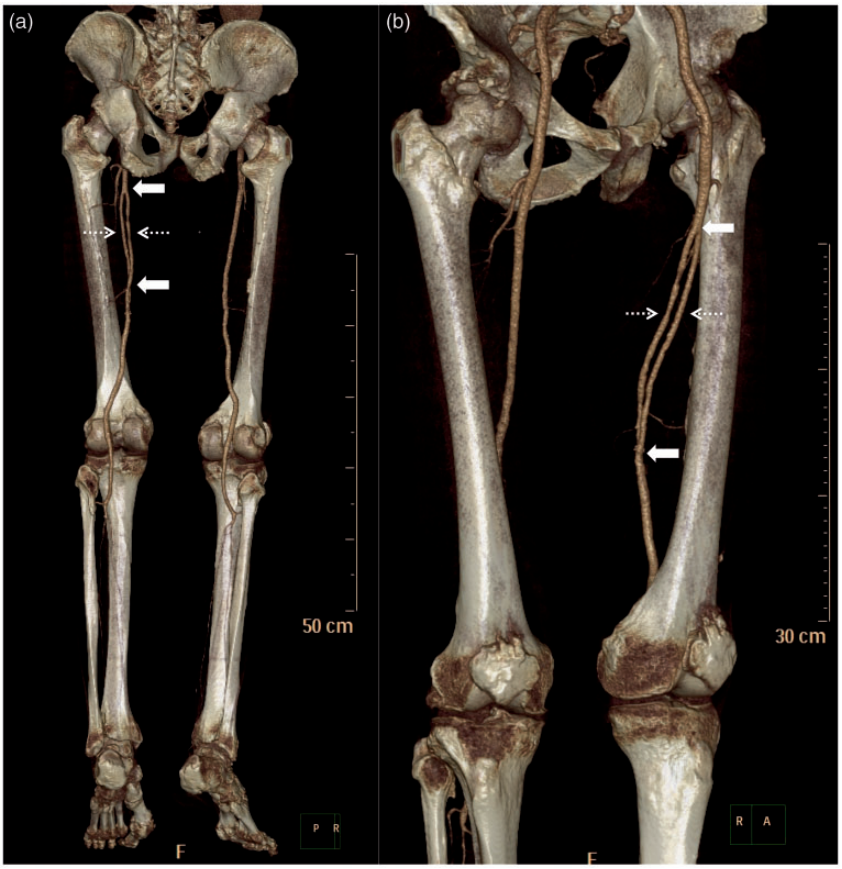

Fig. 2. Three-dimensional volume rendered CT images (a, b) showed a single lumen proximal SFA (solid arrow) bifurcating in the mid femur into two equal lumen duplicated mid SFA (dotted arrows) with distal fusion forming a single lumen vessel (solid arrow).

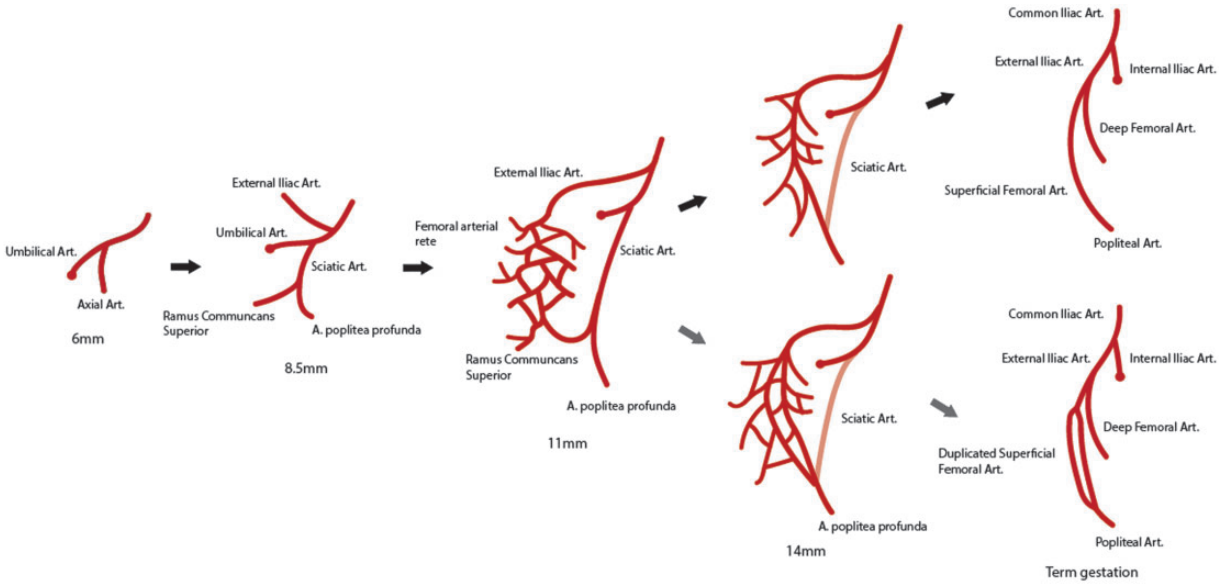

Fig. 3. Illustration of the embryological development of the lower limb arterial system with progress of the gestation defined by the size of embryo (mm). Stages of normal development (black arrows) and proposed development of duplicated SFA (gray arrows). Illustration adopted from Senior (7).

showed a small volume of calcified atherosclerotic plaque disease without causing hemodynamically significant stenosis. The presence of this anatomical variation did change the surgical management with the fibula graft harvested from the right leg. This was a precautionary choice as duplicated SFA was unlikely to cause foreseeable vascular compromise.

Discussion

Duplication of the SFA is an extremely rare anatomical variant with only five reported cases in the imaging literature to the best of the authors' knowledge (2–6). Observation of duplicated the SFA has been described on a variety of diagnostic imaging modalities including digital subtraction angiography (DSA), CTA, color Doppler ultrasonography (CDU), and magnetic resonance angiography. The reported cases were of middle-aged and elderly patients with an age range of 65–97 years. Duplication of SFA most commonly occurred in the proximal or mid segments of the SFA 4–8 cm below the common femoral artery (CFA) bifurcation. The duplicated SFA lumens were symmetric in caliber and were in the range of 4–7 mm in diameter (2–6). Distal convergence of the duplicated SFA typically occurred near the adductor hiatus, with the exception of one case by Akysoy et al. where the duplicated SFA continued as duplicated popliteal arteries (2). The profunda femoral arteries were demonstrated to be normal in all these cases. No major arterial branches were observed from the duplicated SFA, although a small collateral artery branch was identified in one case arising from the duplicated medial limb (3). Two reported cases of duplicated SFA were incidentally discovered on DSA for planning of endovascular intervention for above knee popliteal artery stenosis and intraoperative DSA during embolectomy for acute limb ischemia (2,6). Incidental detection of the variant with CTA occurred while investigating a CFA pseudoaneurysm 2 months post coronary angiography (5). The remaining two cases were encountered for investigation for intermittent claudication (3,4). In the case report by Javerliat et al., DSA showed diffuse atherosclerotic lesions of the duplicated SFA, although the treated critical stenotic lesion (>70%) was at the level of the popliteal artery (3). Kantarci et al. demonstrated duplication of the SFA using CDU where one of the duplicated arteries was found to be severely narrowed due to atherosclerotic change with absent flow noted at the distal segment. The duplication was confirmed on contrast enhanced magnetic resonance angiogram (MRA), however the distal convergence of the vessels was unable to be identified on MRA (4).

Given the paucity of reported cases, it is uncertain if duplication of SFA predisposes to accelerated atherosclerosis. Potential confounding variables include reporting bias of symptomatic patients and seniority of reported patients. Potential pitfalls in imaging interpretation include prior arterial bypass procedures and collateral flow, which can be overcome by knowledge of surgical bypass and ancillary findings of regional surgical clips/materials (4). Lower limb arterial embryology begins at the early stages of embryo development, at 6 mm when the sciatic artery develops as a branch of

the umbilical artery to supply the lower limb bud (7). From the 6–33 mm stage of embryo development, the sciatic artery regresses while the iliac artery system develops. The femoral artery plexus then develops from the iliac artery system to perfuse the developing lower limbs (4). The femoral artery plexus consists of multiple vascular channels named *rami femorales* that develop into wide-channel femoral artery rete, eventually combining to form the superficial and deep femoral arteries. Another vessel of note is the axial artery, which is present from the 6 mm stage, arising from the dorsal root of the umbilical artery (7). During the development of femoral artery rete, the axial artery temporarily acts as the major supply to the lower limb. Duplication of SFA had been hypothesised to be the sequelae of non-union of the femoral artery rete which resulted in the development of two major arterial channels as opposed to one (3). A vessel originating from the axial artery named the ramus communicans superior has been proposed to act as the fusion point of the SFA duplication (3). Further failure of formation of the ramus communicans superior results in failure of distal convergence hence duplication of both the SFA and popliteal artery (2) (Fig. 3).

In conclusion, recognition of duplicated SFA and knowledge of the embryogenesis can avoid misinterpretation and is of clinical relevance for planning of endovascular and vascular bypass surgery.

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