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Visualization of the peripheral vascularity by time-resolved computed tomography: a case report

Anders Svensson[1,2] and Torkel B Brismar[1,2]

Abstract

Runoff computed tomography angiography (CTA) is commonly used to diagnose peripheral artery disease (PAD) of the lower extremities. However, the risk of non-conclusive examination due to suboptimal timing and overrunning the contrast medium bolus is a major pitfall that must be considered. Here we describe two case studies using dynamic time-resolved CTA imaging of the peripheral vascularity.

Keywords

Intravenous contrast agents, computed tomography angiography, CTA, peripheral vascularity

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Introduction

It has been estimated that 12–29% of the elderly population in the United States suffers from peripheral artery disease (PAD) in the lower extremities. In its early stages, the patients suffer from claudication. In the final stage, however, ulceration and gangrene will occur, and amputation may be required if the blood flow cannot be restored. The major risk factors for developing PAD are: age; smoking; hypertension; diabetes mellitus; and hyperlipidemia. The main clinical examination for diagnosing and evaluating its severity is ankle brachial index (ABI) measurement at rest. This entails calculating the ratio of the systolic blood pressure measured at the ankle to the systolic blood pressure measured at the brachial artery. The clinical diagnosis of PAD is defined as ABI at rest $\leq$0.90 (1,2).

In recent years, the development of multidetector computed tomography (MDCT) technology has progressed considerably in terms of time resolution and detector coverage. By using ultra-fast techniques, it is now possible to cover the aortic bifurcation to the ankles in <2 s (e.g. Siemens Somatom Force 731 mm coverage per seconds). This has been enabled by an increasing number of detectors, currently 64–320 rows, covering a volume of 4–16 cm in length. By using a fast-moving table, multiple passages/sequences over the area of interest can be achieved within a few seconds, enabling perfusion and angiographic studies, for example for early brain infarction or liver studies (3–6). Duplex ultrasound remains the gold standard for diagnosing PAD. Compared with digital subtraction angiography (DSA), runoff computed tomography angiography (CTA) has the advantage of being non-invasive and comparatively less resource demanding. Another advantage of runoff CTA in comparison to DSA is the ability of detecting important findings in other organs (7, 8). However, at runoff CTA, there is considerable variability in cardiac output and vascular blood flow among patients. Differences between patients can be compensated for to some extent by using bolus tracking or test bolus technique. Despite these techniques, however, contrast media (CM) timing may still be challenging, usually due to overrunning the CM bolus (9). This is especially the case at asymmetric distribution of steno-occlusive PAD where blood flow is different between the two legs.

[1]Department of Clinical Science, Intervention and Technology at Karolinska Institutet, Division of Medical Imaging and Technology, Stockholm, Sweden
[2]Department of Radiology, Karolinska University Hospital, Stockholm, Sweden

Corresponding author:
Anders Svensson, Department of Clinical Science, Intervention and Technology at Karolinska Institutet, Division of Medical Imaging and Technology, Stockholm 14186, Sweden.
Email: anders.svensson@ki.se

We present an imaging option for the evaluation of the peripheral vascularity using dynamic time-resolved CTA.

CTA scan technique

CTA was performed as two separate scan series. The first series, runoff CTA, was performed using the dual source multidetector (MDCT) Siemens Somatom Definition Flash® (Siemens Healthcare, Forchheim, Germany) applying dual-energy (DE) scanning from the hemidiaphragm down to the forefoot. DE scan parameters included 120/80 kVp and 238/92 mAs.

Using a power injector (Medrad®, Stellant® Dual Head Injector, Bayer, Pittsburgh, PA, USA), a CM bolus injection of 80 mL iomeprol 400 mg iodine per mL, (Iomeron®-400, Bracco Imaging SpA, Milan, Italy) was administered at 6 mL/s through an 18-gauge peripheral venous access inserted into the right antecubital vein. The CM was immediately followed by a 50 mL saline flush at 6 mL/s. Scan start was determined by bolus tracking with 160 Hounsfield units (HU) as the threshold value. After completing runoff CTA, it was observed in both Cases 1 and 2 that the CM bolus had been overrun (Fig. 1). Therefore, it was decided to conduct a second dynamic CTA of the lower legs. The dynamic CTA settings were 70 kVp and 80 mAs. Based on the runoff CTA, scan delay time for the dynamic CTA was set at 20 s. A total of seven iterations were performed with a time resolution of 3 s over a range of 48 cm, from the level of the tibial plateau down to the forefoot (Fig. 2). CM was administered as a bolus injection using 50 mL iomeprol 400 mg iodine per mL injected at 6 mL/s. The dynamic scan data were reconstructed into 0.6-mm slice collimation with an increment of 0.4 mm using kernel B10. The dynamic time-resolved data were exported to a dedicated workstation (syngo.via, Siemens Healthcare, Forchheim, Germany) for motion correction. All three-dimensional (3D) volume-rendering (VR) and postprocessing was done at a separate workstation

Fig. 1. (a) Case 1 and (b) Case 2. Intravenous CM was overrun during CTA runoff.

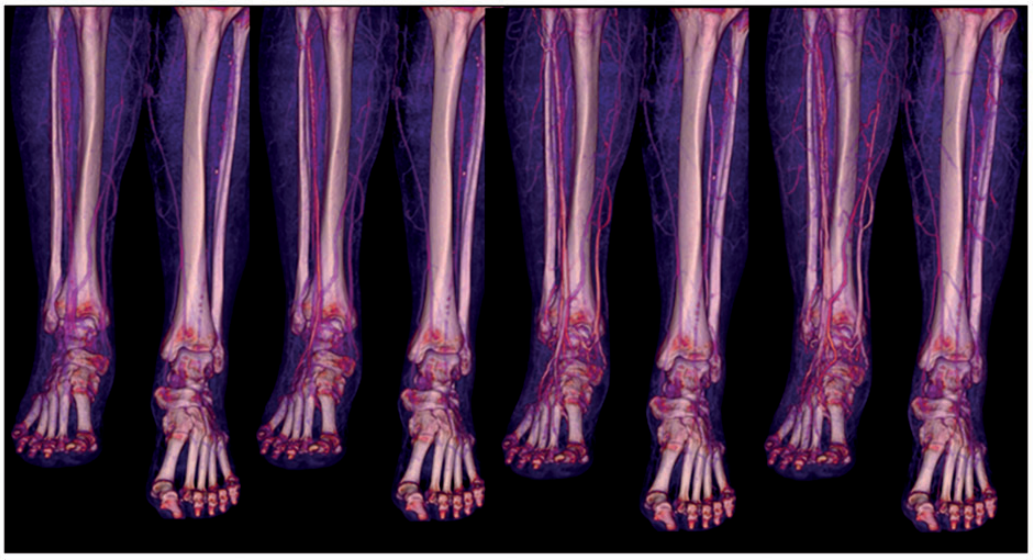

Fig. 2. Case 2: dynamic CTA from four different time points.

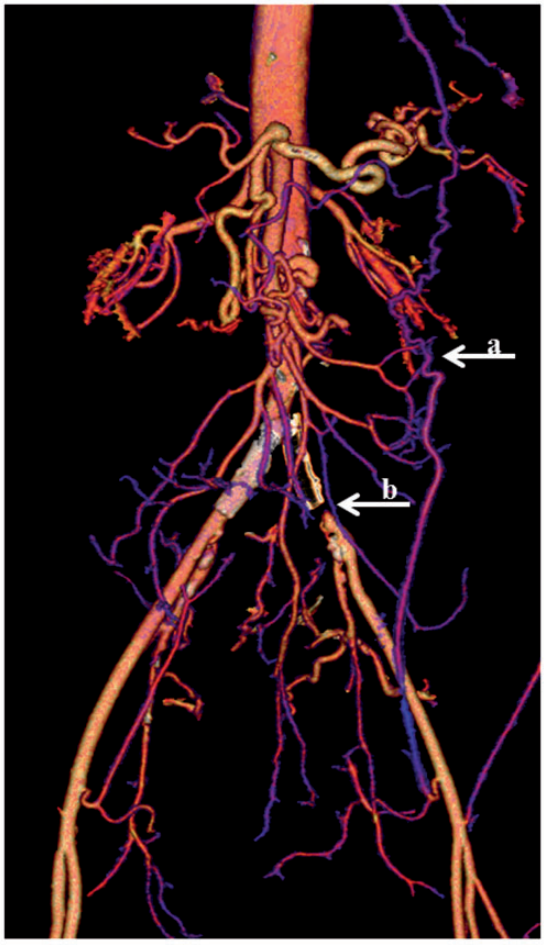

Fig. 3. Case 1: development of collateral vessels from left mammarian artery to the left profunda femoris artery (arrow a). Intraluminal stent occlusion of the left common iliac artery (arrow b).

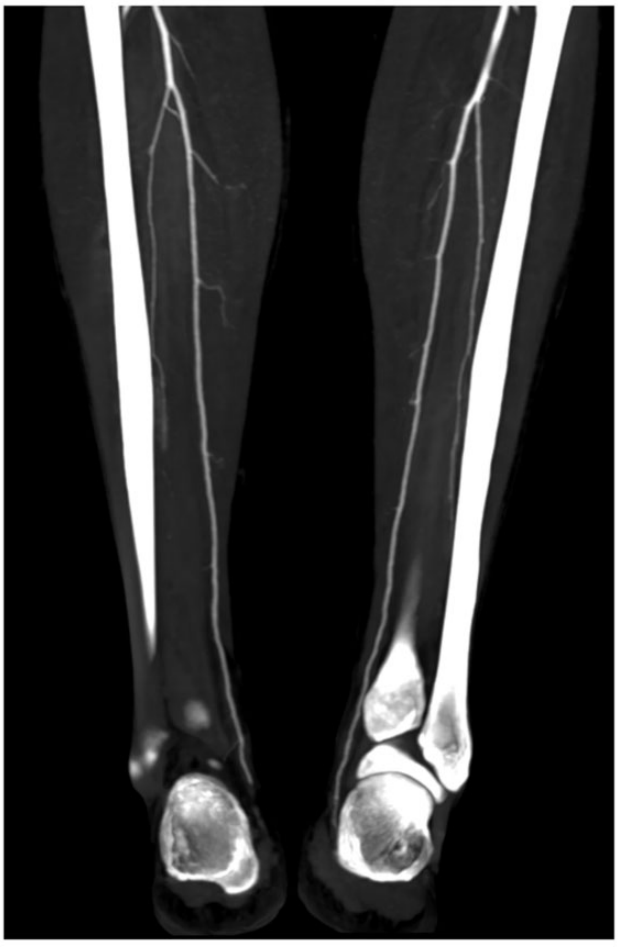

Fig. 4. Case 1: no vascular constriction was detected in the lower extremities.

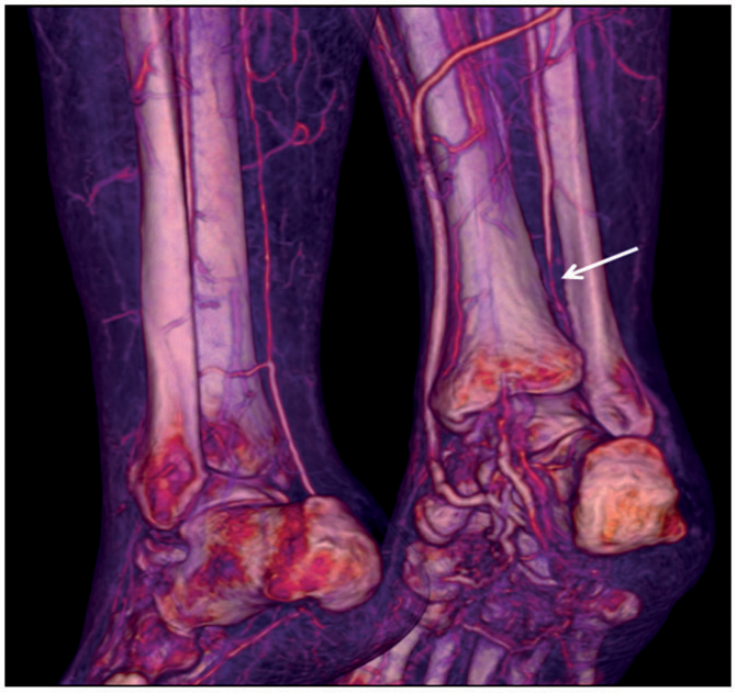

Fig. 5. Case 2: stenosis of the right fibular artery (arrow).

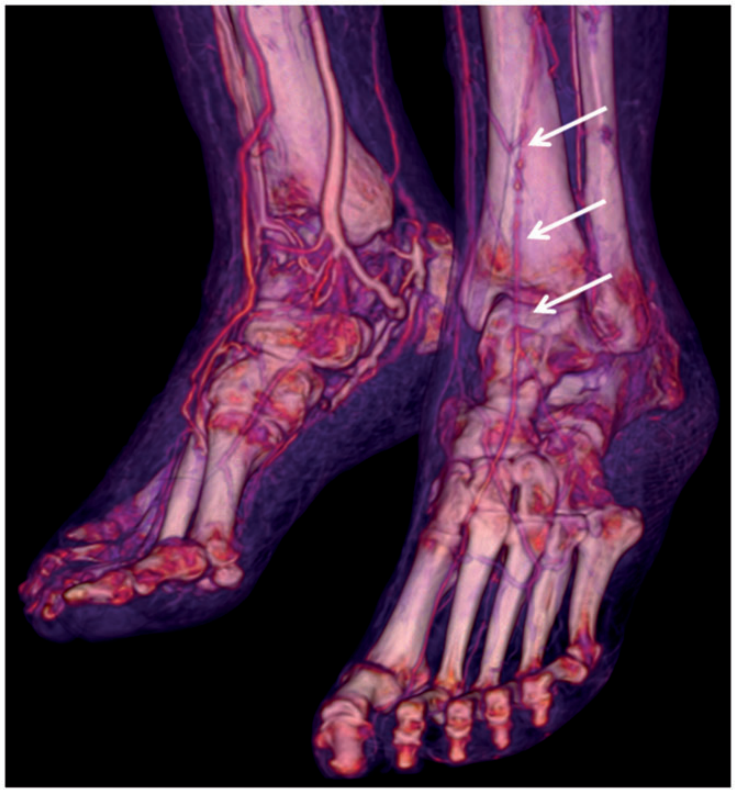

Fig. 6. Case 2: narrow left tibial artery and dorsalis pedis (arrows).

(Advantage Workstation 4.5, GE Healthcare, Milwaukee, WI, USA).

Case 1. A 65-year-old man, a former heavy smoker with a previous history of bilateral stenosis of the iliac arteries treated with angioplasty and selective stenting, was admitted to the emergency department with severe pain in the left lower leg and walking difficulties. Clinical examination revealed no pulsations in the left groin but no loss of sensation in the feet.

Runoff CTA revealed the development of collateral vessels from the left mammarian artery to the left profunda femoris artery (Fig. 3, arrow a) and intraluminal stent occlusion of the left common iliac artery (Fig. 3, arrow b). No vascular constriction of the lower extremities was detected (Fig. 4).

Case 2. An 81-year-old woman, a former smoker with bilateral femoral synthetic bypass, cardiovascular disease, diabetes, ulceration in both feet, and bilateral pain at rest in the lower legs was referred for runoff CTA, which revealed pronounced bilateral pathological changes of the femoral arteries (Fig. 1b).

Dynamic CTA of the lower legs revealed stenosis of the distal part of the right fibular artery (Fig. 5, arrow) and a narrow left tibial artery and dorsalis pedis (Fig. 6, arrows).

Discussion

Both bolus tracking and test bolus technique compensate for variance in CM flow from the start of the injection to the measuring point, usually in the aorta at L3 level. However, when there are severe stenoses in the arteries, blood flow will be compromised and the speed of the blood flow will vary between the legs. When stenosis develops slowly, there is time for collaterals to develop, further increasing the unpredictability of the optimal time point for scanning. In our two case studies, we obtained dynamic time-resolved data from seven scan series, making it possible to visualize the arterial vascular supply. By using a low mA and kV, the contribution to the total radiation exposure from these seven scans was very low compared with the CTA-runoff series, 0.2 mSv versus 5.5 mSv. Both case reports were reviewed by a radiologist with 19 years of experience in CT. Case 1 showed no vascular disease of the lower limbs, which increased the likelihood of a successful interventional restoration of the arterial supply. Somewhat surprisingly, a collateral feeding artery from the left internal mammarian artery to the left profunda femoris artery was discovered. This may be an important finding, not least in view of a possible future heart bypass graft to the left coronary artery. In Case 2 the ulcerations in the feet may be partially explained by the distal stenosis.

In conclusion, CM timing of the peripheral vascularity of the lower limbs is often challenging. By using motion-corrected, dynamic time-resolved CTA scan data, the peripheral vascularity tree can also be visualized in patients with unpredictable blood flow.

Declaration of conflicting interests

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ORCID iD

Anders Svensson http://orcid.org/0000-0001-5685-7255

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