Clinical Imaging 39 (2015) 603–607

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: http://www.clinicalimaging.org

New hybrid reformations of peripheral CT angiography: do we still need axial images?

Ruediger Egbert Schernthaner [a,*], Florian Wolf [a], Gabriel Mistelbauer [b], Michael Weber [a], Milos Sramek [c], Eduard Groeller [b], Christian Loewe [a]

[a] Section of Cardiovascular and Interventional Radiology, Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Währinger Gürtel 18-20, 1090 Vienna, Austria
[b] Institute of Computer Graphics and Algorithms, Technical University of Vienna, Favoritenstraße 9-11, 1040 Vienna, Austria
[c] Commission for Scientific Visualization, Austrian Academy of Sciences, Donau-City Straße 1, 1220 Vienna, Austria

ARTICLE INFO

Article history:
Received 7 October 2014
Received in revised form 16 February 2015
Accepted 10 March 2015

Keywords:
Peripheral arterial occlusive disease
CT angiography
Three-dimensional reformations
Postprocessing

ABSTRACT

Purpose: To quantify the detectability of peripheral artery stenosis on hybrid CT angiography (CTA) reformations.
Methods: Hybrid reformations were developed by combining multipath curved planar reformations (mpCPR) and maximum intensity projections (MIP). Fifty peripheral CTAs were evaluated twice: either with MIP, mpCPR and axial images or with hybrid reformations only. Digital subtraction angiography served as gold standard.
Results: Using hybrid reformations, two independent readers detected 88.0% and 81.3% of significant stenosis, respectively. However, CTA including axial images detected statistically significant more lesions (98%).
Conclusion: Peripheral CTA reading including axial images is still recommended. Further improvement of these hybrid reformations is necessary.

1. Introduction

Peripheral arterial occlusive disease (PAOD), a progressive disease with increasing incidence rates [1], is a diagnosis based on clinical examination and Doppler index measurements. However, prior to treatment, an exact visualization of the extent and severity of disease is mandatory. According to the Trans-Atlantic Inter-Society Consensus [2], not only the relevant lesions but also the complete peripheral vascular tree including in- and outflow should be visualized. Since the introduction of multidetector row CT (MDCT) scanners [3–5] and optimized contrast injection protocols [6,7], the accuracy [8,9] and the clinical utility [10,11] of CT angiography (CTA) for this task have been confirmed by several studies. New MD-CT-scanners deliver an increasing number of axial images, which is of particular advantage for the depiction of intracranial vessels [12]. However, the evaluation of this increasing number of images is a time-consuming challenge for routine clinical practice; thus, 3D reformations are required in addition to facilitate the visualization of complex anatomical structures and to reduce the risk of missed pathologies [13–15]. The limitation of maximum intensity projections (MIPs) with regard to the depiction of calcified vessels, in particular, in the lower leg, was shown by Ofer et al. [16]. Semitransparent volume-rendering (STVR) technique studies were reported to be superior to MIPs as a supplement to axial-source images [17] but failed to reach sufficient accuracy if used alone. Multipath curved planar reformations (mpCPRs) [18] were shown to display the peripheral arterial tree over a significantly greater viewing range than MIPs but are limited by specific predictable artifacts, such as vessels running parallel to the horizontal axis [19]. Thus, the recommended workflow for the evaluation of peripheral CTA consists nowadays of a combination of axial and reformatted images [20]. To overcome the limitation of different 3D reformations, a hybrid reformation that combines MIP and mpCPR information into one image was developed. This new algorithm offers the capabilities of mpCPR to visualize the lumen of severely calcified vessels and inside stents and also shows a good MIP-like overview of the complete vessel tree including collateral vessels. Thus, the aim of the present study was to evaluate the accuracy of these recently developed hybrid reformations for the detection of significant stenosis in patients with PAOD, without the time-consuming review of axial images. Digital subtraction angiography (DSA) served as the standard of reference.

2. Materials and methods

This retrospective study was approved by the local institutional review board. Fifty consecutive patients with a clinical diagnosis of PAOD who underwent both CTA and intraarterial DSA of the peripheral arteries within 30 days (mean: 12 days; range: 1–30 days) were included in the present study.

* Corresponding author. Section of Cardiovascular and Interventional Radiology, Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Währinger Gürtel 18-20, 1090 Vienna, Austria. Tel.: +43-1-40400-58020; fax: +43-1-40400-58300.
E-mail addresses: ruediger.schernthaner@meduniwien.ac.at (R.E. Schernthaner), florian.wolf@meduniwien.ac.at (F. Wolf), gm@cg.tuwien.ac.at (G. Mistelbauer), michael.weber@meduniwienac.at (M. Weber), milos.sramek@oeaw.ac.at (M. Sramek), groeller@cg.tuwien.ac.at (E. Groeller), christian.loewe@meduniwien.ac.at (C. Loewe).

http://dx.doi.org/10.1016/j.clinimag.2015.03.005
0899-7071/

2.1. CT angiography

Peripheral CTA studies were performed from the level of the celiac trunk to the mid-foot on a 16-row, MDCT scanner (Somatom Sensation 16, Siemens Medical Systems, Erlangen, Germany) using a detector configuration of 16×0.75 mm. Tube voltage was set to 120 kV, reference mAs was set to 130. A table increment of 14 mm was combined with a gantry rotation time of 0.5 s, leading to a table speed of 28 mm/s.

Iomeprol, a nonionic contrast agent containing iodine 400 mg/mL (Iomeron 400, Bracco, Milan, Italy), was injected using a standardized biphasic contrast injection protocol [7] with a programmable power injector (Angiomat CT, Digital Injection System, Liebel-Flarsheim Company, Cincinnati, OH, USA). The first 25 ml of contrast agent were injected at a flow rate of 4.5 ml/s. For the remaining scan time (mean 27.4 s), the flow rate was reduced to 2.3 ml/s, resulting in a mean injected contrast agent volume of additional 63.0 ml, followed by a saline flush of 40 ml injected at a flow rate of 2.3 ml/s.

With a delay of 8 s after starting the contrast injection, reference scans above the aortic bifurcation were acquired every second until the enhancement within the aorta exceeded 150 HU.

2.2. Postprocessing of CTA data

Thick axial sections of about 1.5 mm were reconstructed at 0.75 mm intervals and transferred to a prototype workstation, developed in a multidisciplinary project by technicians, computer scientists, and radiologists, as described previously [21–23]. This workstation contains several semiautomatic, postprocessing algorithms that offer segmentation for MIPs and vessel tracking for mpCPRs. By calculating not only the vessel centerline but also the vessel diameter, the workstation allows the projection of the vessel tree of the mpCPRs onto the MIPs, resulting in a new hybrid reformation (Fig. 1). In these hybrid reformations, the main vessels of the lower extremities are shown using the mpCPR technique, whereas the background including collateral vessels is depicted using MIP technique. All reformations were generated over a viewing range of 180° in 9° intervals.

2.3. Intraarterial DSA

DSA was performed on a digital subtraction unit (Multistar, Siemens Medical Systems) with a power injector for nonionic contrast medium (Iomeprol 300 mg, Bracco).

Puncture sites and directions were selected based on the location of the lesions to be treated and the vessel geometry of each patient as depicted with routine CTA.

Thirty-eight patients (76%) underwent retrograde arterial puncture. In 7 of them (14%), the stenotic lesion to be treated was in the ipsilateral iliac arteries and an aortic flush technique was applied for the depiction of the ipsilateral leg. In the other 31 patients (62%), an aortogram was acquired, followed by a crossover maneuver. In 16 of these patients, the vascular segments of only the contralateral leg were completely depicted. In 20% of the patients (n= 10), an antegrade arterial puncture was performed, and only the femoro-popliteal and the infrapopliteal arteries of the ipsilateral leg were visualized for comparison with CTA. In the remaining two patients, puncture of the left brachial artery was the only suitable access, and the arteries of both legs were depicted during treatment.

2.4. Image interpretation

The images were anonymized, and the reviewers were unaware of the clinical history. In each leg, 20 arterial segments were defined (Fig. 2), and the severity of the most stenotic lesion of each segment was graded visually using the same 4-point scale for DSA and CTA images: Grade 0 (*healthy*); Grade 1 (1–49%, *mild stenosis*); Grade 2 (50–99%, *severe stenosis*); and Grade 3 (100%, *occlusion*).

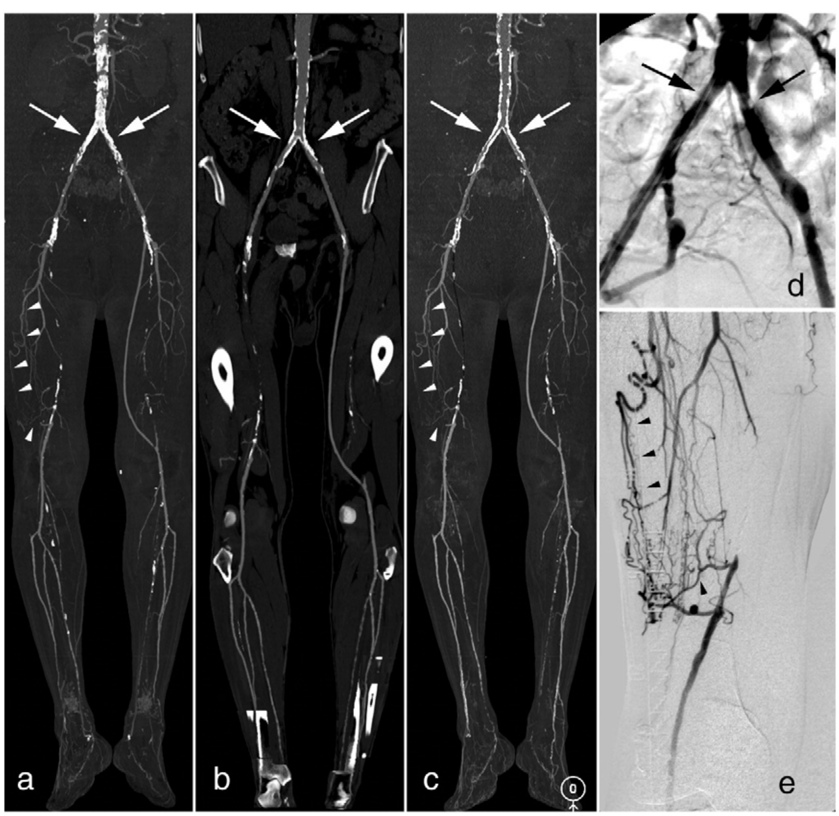

Fig. 1. A 64-year-old male patient with a known occlusion of the right superficial femoral artery and a femoro-popliteal bypass on the left was referred for CTA due to PAOD IIb in the right leg. (a) MIP showed collateral vessels (arrowheads), but the severely calcified iliac arteries could not be evaluated (arrows); (b) On mpCPR, stenosis in both iliac arteries was detected (arrows), but collateral vessels were not depicted; (c) Only the hybrid reformation depicted both iliac stenosis (arrows) and the collateral vessels (arrowheads); (d+e) Preoperative DSA confirmed the iliac stenosis (arrows) and the collateral vessels (arrowheads).