Volumetric CT perfusion technique for assessment of PTA outcome in patients with Critical Limb Ischemia: A feasibility study

Poster No.: C-0661
Congress: ECR 2018
Type: Scientific Exhibit
Authors: N. Galanakis¹, T. G. Maris², N. Kontopodis¹, E. Kehagias¹, C. Ioannou¹, N. Kosidekakis¹, K. Perisinakis³, A. H. Karantanas¹, D. Tsetis¹; ¹Heraklion/GR, ²Heraklion, Crete/GR, ³Iraklion/GR
Keywords: Image verification, Arteriosclerosis, Contrast agent-intravenous, Computer Applications-Detection, diagnosis, Angioplasty, Fluoroscopy, CT-Quantitative, CT-Angiography, Interventional vascular, Extremities, Cardiovascular system, Ischaemia / Infarction
DOI: 10.1594/ecr2018/C-0661

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.
Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.
Aims and objectives

Peripheral arterial disease (PAD) characterizes the impairment of blood flow to the limbs as a result of stenoses or occlusions of the lower limb arteries [1]. The prevalence of PAD is in the range of 3-10% [2] and the major risk factors are cigarette smoking, diabetes mellitus, hyperlipidemia and hypertension [3,4]. The presentation of PAD is varied and may appear as asymptomatic arterial disease, symptomatic disease presenting as classic or atypical intermittent claudication or critical limb ischemia (CLI) defined as recurring ischemic rest pain, ulceration or gangrene of foot or toes [3]. Staging was performed with the Fontaine or Rutherford classification [5].

Evaluation of PAD includes clinical history, physical examination, measurement of ankle-brachial index [6] and radiological investigations such as color duplex ultrasound, computed tomography angiography (CTA), magnetic resonance angiography (MRA) and digital subtractive angiography (DSA) [3,7]. These imaging modalities provide significant information about the distribution of macrovascular lesions of the limbs such as stenoses or occlusions but not for the local microvascular perfusion of lower extremities.

Non-conventional imaging techniques such as MR diffusion weighted imaging and MR perfusion weighted imaging are used for the diagnosis and the selection of therapeutic treatment for many diseases, especially for brain parenchyma [8] and the myocardial perfusion [9]. Apart from MR perfusion techniques, CT can provide qualitative and quantitative evaluation of tissue perfusion. CT perfusion technique is useful for diagnosis of cerebral ischemia [10], for diagnosis and evaluation of the response to anticancer treatment in patients with liver tumors [11] and detection of hemodynamically significant coronary stenosis in patients with coronary artery disease [12].

The purpose of this study is to emerge hypoperfusion of lower limbs in patients with CLI using quantitative perfusion multidetector-row computed tomography (MDCT) and estimate perfusion parameters changes after successful PTA.
Methods and materials

Study design

This is a prospective single-center study aiming to examine the role of quantitative perfusion MDCT in the evaluation of hypoperfusion in patients with CLI and the changes of quantitative parameters after PTA. All enrolled patients underwent diagnostic lower limb CTA before endovascular treatment and foot CT perfusion examination before and within 1st week after endovascular treatment. Exclusion criteria included allergy to iodinated contrast, moderate or severe renal impairment (GFR < 45 mL/min), congestive heart failure and severe cardiac rhythm anomalies. Patients were followed-up with clinical examination at 1, 3, 6 and 12 months and color Doppler ultrasound combined with clinical examination on an annual basis.

The study was approved by the local ethic committee and all patients signed informed consent prior to examination.

Study population

Ten patients (7 male, 3 female) with PAD enrolled in this study and underwent quantitative perfusion MDCT of foot with an appropriate imaging protocol. The median age was 69.5 years (range 51-84 years). All patients presented with CLI and according to Rutherford classification of PAD, one patient was allocated to class 4 PAD, six patients to class 5 PAD and three patients to class 6 PAD. The main risk factors were hypertension (n=8), hyperlipidemia (n=7), diabetes mellitus (n=7), smoking (n=9) and coronary artery disease (n=3).

Imaging protocol

All studies were performed with a 128-slice CT scanner (Revolution GSI, GE Healthcare, USA). Patients were examined in the supine position and the angiography scan was obtained in the craniocaudal direction. The position of both feet was stabilized with a sticky tape during the examination.

CTA was performed with a standard CTA protocol from the diaphragm to the feet after injection of 110 ml of iodinated non-ionic contrast medium followed by 50 mL of saline solution at a flow rate of 4 mL/s via an 18 G intravenous catheter placed in the antecubital vein.

The patients also underwent foot perfusion examination prior to diagnostic CTA and within 1st week after the endovascular treatment. The volume acquisition (14 cm) was selected to include the entire foot and ankle. A cine mode technique was carried out with
the following parameters: 0.625 mm × 64 mm collimation (coverage 40 mm), 0.4 s gantry rotation time, pitch of 1.375, 1.25 mm reconstruction interval thickness, number of passes 28, time per pass 1.7 s, 80 kVp tube voltage, reference tube current 220 mAs and total acquisition time 47.7 s. Images were obtained after injection of 40 ml of iodinated non-ionic contrast medium followed by 30 mL of saline solution at a flow rate of 4 mL/s.

Image analysis

CT perfusion images were transferred to a dedicated workstation (AW server 3.2, GE Medical Systems) and analyzed using specific CT software (CT Perfusion 4D, GE Medical Systems). CT perfusion parameter maps of various hemodynamic parameters such as blood volume [BV], blood flow [BF], permeability surface [PS] and mean transit time [MTT] were created. Subsequently, multiple ROIs were placed around the entire foot, on the dermis and muscles tissues on the dorsal and plantar aspect of the foot and the heel in the same region in the pre- and post-procedure examination. The change in the relative perfusion parameters before and after endovascular treatment was calculated.

Statistical analysis

Statistical analysis was performed with MedCalc (version Medcalc Software, Mariakerke, Belgium). Wilcoxon signed rank tests were used to compare pre and post-procedure perfusion parameters and p-values were estimated for each comparison. The relative change in ABI was also tested with Wilcoxon signed rank test. A p-value < 0.05 was considered statistical significant.
Fig. 1: CT perfusion, axial, permeability surface map of left foot.

© University of Crete, University Hospital of Heraklion - Heraklion/GR
Fig. 2: CT perfusion, axial, blood volume map of left foot.

© University of Crete, University Hospital of Heraklion - Heraklion/GR
Fig. 3: CT perfusion, axial, blood flow map of left foot.

© Univeristy of Crete, University Hospital of Heraklion - Heraklion/GR
Results

Clinical outcome

Technical success was achieved in all patients (10/10). There were no major complications after endovascular treatment apart from femoral artery pseudoaneurysm in one patient which was treated with US-guided compression. There was significant clinical improvement in all patients and the ankle brachial index (ABI) increased from 0.34 ± 0.15 to 0.76 ± 0.21 after revascularization (p<0.05). The patients were followed-up with clinical examination and color Duplex ultrasonography for a mean duration period of 8 months (range 6-12). During follow-up, 2 patients died due to non-procedure related causes (colon cancer, myocardial infarction) and 2 patients underwent minor amputation (toe, transmetatarsal).

Perfusion evaluation

Successful revascularization led to a significant change in perfusion parameters. After PTA, mean PS increased from 3.12 ± 2.03 to 9.40 ± 3.52 ml/100g/min, mean BV increased from 1.65 ± 0.80 to 4.78 ± 1.38 ml/100g, mean BF increased from 16.74 ± 5.00 to 32.85 ± 6.22 ml/100g/min and mean MTT decreased from 7.56 ± 1.69 to 4.28 ± 0.77 s (p<0.05). The mean dose-length product of CT perfusion examination was 1412.4 mGy*cm and the mean effective dose was 0.28 mSv (conversion coefficient k factor was 0.0002 mSv*mGy-1*cm-1).
Fig. 4: A 84-year-old male patient with CLI of right lower extremity. DSA showed total occlusion of right distal SFA.

© University of Crete, University Hospital of Heraklion - Heraklion/GR
Fig. 5: After successful PTA, DSA showed significant flow restoration.
Fig. 6: CT perfusion, axial, blood volume map of right foot before PTA.

© University of Crete, University Hospital of Heraklion - Heraklion/GR
Fig. 7: CT perfusion, axial, blood volume map of right foot after successfull PTA. There was significant increase in BV especially in the peripheral dermal layer.

© Univeristy of Crete, University Hospital of Heraklion - Heraklion/GR
Fig. 9: Box-and-whisker plot of blood volume mean values before and after PTA.

© University of Crete, University Hospital of Heraklion - Heraklion/GR
Fig. 8: Box-and-whisker plot of permeability surface mean values before and after PTA.

© University of Crete, University Hospital of Heraklion - Heraklion/GR
Fig. 10: Box-and-whisker plot of blood flow mean values before and after PTA.
Fig. 11: Box-and-whisker plot of mean transit time mean values before and after PTA.

© University of Crete, University Hospital of Heraklion - Heraklion/GR
Conclusion

The present study demonstrates the statistical significant change in perfusion parameters in patients with CLI after successful revascularization. We also observed that the perfusion parameter changes were greater in the dermal layer in comparison with muscles tissues.

In conclusion, foot CT perfusion examination may be a useful modality for the diagnosis of foot hypoperfusion and estimation of PTA outcome in patients with CLI. The information of this examination could be used both to predict the outcome of patients with CLI and plan the revascularization strategy according to CT perfusion results.