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Intra-arterial MR-angiography on an open-bore MR-scanner compared to digital-subtraction angiography of the infra-popliteal runoff in patients with peripheral arterial occlusive disease

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Abstract

Purpose: To evaluate the diagnostic value of contrast-enhanced intra-arterial 3D-MR-angiography (IA-MRA) of the infra-popliteal arteries in an open-bore magnet. Number, severity of arterial lesions, and artefacts were compared to routinely performed intra-arterial digital-subtraction angiography (IA-DSA) in patients suffering from symptomatic peripheral arterial occlusive disease (PAOD).
Material and methods: Fifteen patients admitted for PAOD underwent percutaneous transluminal angioplasty (PTA) by IA-DSA. After PTA, IA-MRA of the infra-popliteal station was performed on an open-bore 1.5 T MR-scanner applying a low dose intra-arterial contrast-enhanced 3D-gradient-echo-MRA with gadopentate dimeglumine. The reading was performed by three blinded readers distinguishing moderate (≤50%), significant stenoses (51–99%) and vessel occlusions. Imaging artefacts were recorded and binary classified as not disturbing or compromising the observation of the arterial tree.
Results: Overall IA-DSA revealed 36 moderate stenoses (≤50%), 38 significant stenoses (51–99%), and 10 vessel occlusions. For the detection of significant stenoses and occlusions, the overall sensitivity, specificity, positive predictive value, negative predictive value and accuracy of IA-MRA were 96%, 83%, 88%, 94% and 90%. The only observed artefact was venous overlay in four stations. The readout was not hampered in any case.
Conclusion: Intra-arterial contrast-enhanced 3D-gradient-echo-MRA on an open-bore MR-scanner offers an acceptable diagnostic accuracy in diagnosing peripheral arterial occlusive disease in the infra-popliteal region and correlates well with DSA.

Keywords: Intra-arterial magnetic resonance-angiography; Intra-arterial digital-subtraction angiography; Open-bore MR-scanner; Contrast media; Peripheral arterial occlusive disease

1. Introduction

Three dimensional (3D) intra-venous contrast-enhanced magnetic resonance angiography proved to be a valuable alternative to conventional X-ray iodinated contrast-enhanced angiography for accurate vessel depiction in patients with peripheral arterial occlusive disease (PAOD) [1,2]. MR-angiography offers several advantages compared to intra-arterial digital-subtraction-angiography (IA-DSA) such as the lack of potentially nephrotoxic iodinated contrast media, the reduction of allergic reactions and the absence of radiation exposure for patient and investigator. Furthermore MR angiography provides beyond the 3D visualization of the arterial vessel tree an excellent soft tissue and bone contrast.

These favourable qualities and the promising features of MR-angiography animated researchers to delve into therapeutic approaches with MR-guided endovascular interventions. Although there is already data published reporting on successful MR-directed interventional procedures [3–6], no hardware certification exists so far especially for guidewires in order to perform MR-guided PTA in a clinical setting.

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A further important topic and matter of current research activities is the development of faster data acquisition and high resolution MR-imaging sequences for the evaluation of the pre- and postinterventional arterial vessel status and to guide interventional devices. Since for endovascular procedures an intra-arterial introducer sheath is needed it seems reasonable to perform a direct intra-arterial contrast media administration rather than a conventional intra-venous run. Recently several phantom and animal studies demonstrated that an intra-arterial MR-angiography (IA-MRA) protocol is feasible with significantly lower gadolinium doses compared to intra-venous MR-angiography (IV-MRA) and that less synchronization for data acquisition is needed for IA-MRA as opposed to IV-MRA [7–9]. Applying this knowledge, a low-dose injection protocol for humans was developed for IA-MRA, which showed to be valid for the arterial flow conditions of the infrainguinal runoff in PAOD patients [10]. Further studies were conducted to validate the diagnostic value of IA-MRA compared to IA-DSA in humans [11,12]. Whereas IA-MRA on a conventional MR-scanner via a percutaneous introducer sheath in the superficial femoral artery reveals a very good correlation to IA-DSA in the femoro-popliteal axis, the results especially for the distal infra-popliteal arterial runoff are slightly inferior [11]. One study revealing a high correlation between IA-DSA and IA-MRA in the infrao-popliteal runoff unfortunately considered only the proximal crural station [12]. However, the evaluation of the entire infra-popliteal runoff is not only important for diagnostic evaluation but also for therapeutic PTA approaches in a clinical setting.

The trend towards interventional MRA is enhanced by the recent introduction of open-bore MR-scanners. With a gantry diameter of 70 cm the access to the femoral puncture site is facilitated and the manipulation of guidewires and catheters during interventions may be simplified. Additionally, these open bore scanners are equipped with a high performance gradient system that allows fast data acquisition.

Thus, the purpose of our study was to prospectively evaluate the accuracy of IA-MRA on an open-bore magnet compared to IA-DSA applying an optimized scanning and injection protocol for the depiction of significant (51–99%) stenoses and vessel occlusions in the entire infra-popliteal station in patients with PAOD.

2. Material and methods

2.1. Patients

In this prospective study 15 patients (11 male, 4 female, age range: 56–86 years, mean age 72 ± 8.4 years, median age 75 years) were enrolled within an 8-month period in 2005 and 2006. All patients suffered from PAOD stage II (intermittent claudication) according to the Fontaine classification. They were referred after a clinical examination and a duplex sonography (ATL HDI 5000, Philips, Best, The Netherlands) for percutaneous transluminal angioplasty (PTA) by IA-DSA (13 superficial femoral artery, 4 popliteal artery).

Table 1
Patients clinical characteristics

Characteristic	Value
Number of patients	15
Average age ± S.D. years	72 ± 8.4
Male:female ratio	2:1
Risk factors	
Diabetes mellitus	3/15
Hyperlipidemia	6/15
Hypertension	15/15
Smoking-history	12/15
Site of PTA (X-ray guided)	
Femoral	8 right, 5 left
Popliteal	1 right, 3 left
Access for PTA (X-ray guided)	
Antegrade	15

The baseline clinical data in our study group are presented in Table 1. The protocol was approved by our institutional review board and informed consent was obtained from every patient before entering the study.

2.2. Inclusion and exclusion criteria

Inclusion criteria were significant focal symptomatic atherosclerotic stenoses in duplex ultrasound of 51–99% and/or occlusions within the femoro-popliteal axis, suitable for PTA. In order to assure good inflow conditions after PTA of the femoro-popliteal station and to allow an antegrade femoral access, significant stenoses of the iliac axis were clinically ruled out by oszillography and duplex ultrasound. Exclusion criteria were all general contraindications to MR-imaging such as ferromagnetic implants, pacemakers, or claustrophobia.

2.3. IA-DSA

Patients were referred to the interventional unit of our radiological department for DSA guided PTA. The examinations were performed by two interventional radiologists. The individual PTA procedures performed in each patient are listed in Table 1. Before angioplasty 5000 IU of heparin were administered. Contrast material was manually injected over the side port of the antegrade 4-F 10 cm introducer sheath (Terumo Radiofocus introducer II, Interleuvenlaan, Leuven, Belgium); a total of 9 mL of contrast material was injected in the femoral and crural regions, with saline-to-contrast media ratios of 1:1 and 1:2, respectively. No vasodilatation drugs were administered during intra-arterial DSA. The number of projections was at the discretion of the angiographer. Following PTA of the femoro-popliteal station the infra-popliteal runoff was documented by intra-arterial DSA for the exclusion of peripheral embolisation. These DSA images of the infra-popliteal station served as the reference standard. After intra-arterial DSA the introducer sheath remained in the common femoral artery with the tip in the proximal superficial femoral artery. During the patient transport from the DSA intervention suite to the MR-unit on a stretcher, the introducer sheath was flushed by an isotonic