MR Angiography of Hemodialysis Access Grafts and Fistulae using Selective Contrast Injection and Flow Interruption

Clemens BOS¹, Johannes H.M. SMITS², Jan J. ZIJLSTRA², Wil A.M.A. VAN DER MARK², Peter J. BLANKESTIJN², Chris J.G. BAKKER², Max A. VIERGEVER³, Willem P.Th. MALI²
¹Image Sciences Institute, AZU, Room E01.334, Utrecht, The Netherlands; ²University Medical Center Utrecht, Heidelberglaan 100, Utrecht, The Netherlands; ³Image Sciences Institute, AZU, E01.334, Utrecht, Netherlands;

Introduction
MR is a potentially attractive modality for evaluation of hemodialysis access anatomy and function. Results obtained so far, both with conventional and contrast-enhanced (CE) MRA, have been disappointing. The large variation in flow rates (up to 3 liters/min) and associated flow artifacts complicates interpretation of the MRA images, especially in the critical areas near stenoses and anastomoses.

In this work, we show that flow artifacts can be completely eliminated by interrupting the flow with a cuff, as is familiar from X-ray angiography, and local administration of a contrast-agent.

Methods
All examinations were performed on a 1.5-T clinical scanner (ACS-NT, Philips Medical Systems, Best). Patients were imaged in supine position, entering the scanner feet-first to facilitate communication. A 17-gauge plastic needle was inserted in the hemodialysis access, fixed with tape, and connected to two 30-ml syringes containing twentyfold diluted Gd-DTPA (Magnevist, Schering, Berlin) via 100-cm luerlock tubing. A cuff was wrapped around the upper arm. A 10×40-cm surface coil on the forearm was used for signal reception.

Filling of the access was monitored on an in room LCD-screen, using a 2D gradient echo sequence with complex mask subtraction, acquisition time 0.9 s. First, access flow was reduced by inflating the cuff to 100 mmHg. Contrast was hand-injected until the access downstream of the puncture site was filled. Then, by increasing the cuff pressure to over 250 mmHg, flow in the access was stopped, enabling retrograde filling of the upstream parts of the access. When the filling of the access was considered sufficient and stable, a 3D acquisition (TR/TE/α = 6.1 ms /1.8 ms/45 °, acquired resolution 1.0×1.0×0.8 mm³) was started at the scanner. In the first two patients, the cuff was inflated immediately to over 250 mmHg, before contrast injection was started.

The feasibility of the method was examined in eight patients, four with a PTFE loop graft on the forearm and four with a Cimino-Brescia fistula. The study was approved by the Institutional Review Board, and informed consent was obtained from all patients.

In the first four patients, CE-MRA was compared to non-contrast-enhanced MRA: viz. 2D time-of-flight and 3D phase contrast. In the last four patients, CE-MRA was compared to digital subtraction angiography (DSA).

The images were reviewed by an experienced vascular radiologist. It was assessed whether the accesses were completely visualized; i.e. from the arterial anastomosis, via the loop to the venous anastomosis and the native vein for PTFE loop grafts, or containing the anastomosis and native vessels up to the elbow for Cimino-Brescia fistulae. When DSA was available morphology was compared.

Results
In six patients the access was completely visualized (Fig. 1). In the first two cases, both PTFE-grafts, filling of the venous anastomosis was poor, which was remedied by lowering the cuff-pressure during the first phase of injection. Images were free of flow related artifacts: all narrowings on MRA corresponded to a similar narrowing on DSA.

Examination time was 25 minutes (range 15-35). Preparation of the patient adds 15 minutes to the exam. An average of 3.2 ml of pure gadolinium was used (range 2.5-4.5 ml), including repeated examinations in four patients. During filling and subsequent 3D imaging, the cuff was inflated for an average of 82 s per series (range 69-93 s), which was well tolerated by all patients.

Discussion
Selective CE-MRA with flow interruption provides high quality 3D images of hemodialysis access grafts and fistulae that are free of flow artifacts. Injecting directly into the access reduces the required contrast dose tenfold (1,2), and offers the possibility to repeat the exam. The issue of synchronizing acquisition and peak contrast concentration, which is a problem of intravenously injected 3D CE-MRA, is circumvented.

In combination with direct MR venography to visualize the runoff vessels (3), and phase contrast flow measurements, the proposed technique allows evaluation of both hemodialysis access function and anatomy on MR.

References