Fast dynamic, high resolution contrast-enhanced MRA of dialysis shunts using the CENTRA keyhole technique

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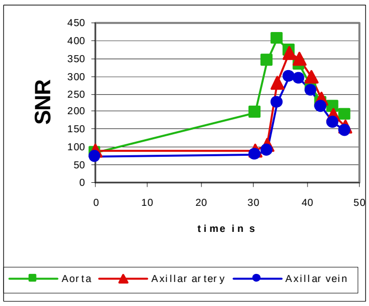
Introduction: Investigation of hemodialysis shunts with high-flow conditions is limited with conventional CE-MRA due to insufficient temporal resolution, resulting in arteriovenous overlay. In order to allow the MR angiographic assessment, the use of a fast dynamic, 3D-CENTRA keyhole sampling sequence permitting high spatial resolution angiograms with additional dynamic information at high temporal resolution was evaluated in 12 hemodialysis patients. The purpose of this prospective clinical study was to evaluate image quality, diagnostic value and quantitative contrast-enhancement characteristics in order to prove feasibility in patients with hemodialysis shunts.

Methods: 12 consecutive patients (5 upper-arm, 7 lower-arm shunts, 11 men, 1 woman, average age=60.25), clinically suspicious of shunt failure, were investigated on a 1.5T clinical MR scanner (Philips Medical Systems) using fast dynamic, high resolution contrast-enhanced MRA with CENTRA keyhole. In the keyhole-based technique [Ref], a series of 8-10 dynamic central k-space portions is acquired during the contrast passage, followed by a full reference data set using a 3D-gradient-echo sequence (TR=3.5ms / TE=1.29ms / flip-angle=45° / 1.28x0.88x1.5mm^3 with zero-filling / 70slices / CENTRA / Sense factor=2 for the upper-arm and TR=3.9ms / TE=1.4 ms / flip-angle=45° / 1.14x0.82x1.5mm^3 with zero-filling / 55 slices / CENTRA / Sense factor=2 for the lower-arm, number of dynamics is adjusted to flow). The peripheral k-space data set is extracted from the keyhole reference data set and filled with each of the central k-space portions to finally reconstruct high-resolution dynamic datasets. Central k-space percentage was set to 10% for upper- and 25% for lower-arm shunts allowing a temporal resolution during the bolus passage of 2.2 s and 4.1 s, respectively. Bolus timing was performed with a contra-lateral intravenous bolus injection of 1-3 ml gadolinium. Angiograms were acquired with 0.4 ml/kg bw of i.v. Gd-DOTA at an injection rate of 2-3 ml/s. Overall image quality and diagnostic value were assessed by two experienced readers in consensus on a three point scale using the MIP reconstructions. Signal-to-noise ratio (SNR), vessel-soft tissue contrast-noise-ratio (CNR) and dynamic enhancement characteristics were assessed for all patients.

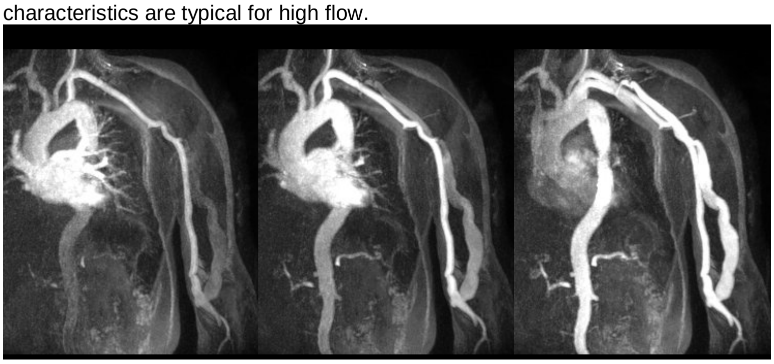
Results and discussions: All 12 patients were successfully examined. The acquisition time for a whole 3D volume set of the upper- or lower-arm was 2.2 s and 4.1 s, respectively. The examined region covers the area from the aorta to the finger tip. The dynamic angiograms allowed differentiating the arterial and venous filling despite high flow conditions [Fig.1]. Image quality was rated as good in n=10 cases and intermediate in n=2 cases. All studies were diagnostic and the following pathologies could be assessed: n=2 stenoses of the arterial branch, n=2 within the fistula, n=13 of the venous branch and n=3 aneurysms.



	Peak Aorta	Peak axillar artery	Peak shunt	Peak axillar vein
Bolus delay	35.76 ± 7.46	36.64 ± 7.21		40.04 ± 8.33
SNR	225.5 ± 170.1	205.3 ± 179.1	225.9 ± 319.7	176.3 ± 164.2
CNR	27 ± 34.4	24.15 ± 28.77	78.6 ± 99.8	23.3 ± 27.6

Tab 1: Bolus delay, SNR, CNR for all n=12 patients. Note the short interval between arterial and venous bolus with 3.4 s demonstrating the high temporal resolution of the method. Fig. 2 (left): Example of SNR dynamics for a single patient with an upper-arm shunt.

In most shunts high SNR values were detected in both the arterial and venous branches (Table 1 / Fig. 2). Due to higher standard deviations of noise, CNR was reduced. This might be inherent to the method, but did not limit the diagnostic performance. Peak delays between the arterial and venous phases were extremely short (mean = 3.4s). Contrast enhancement was merely reduced during bolus passage. Contrast dynamics and characteristics are typical for high flow.



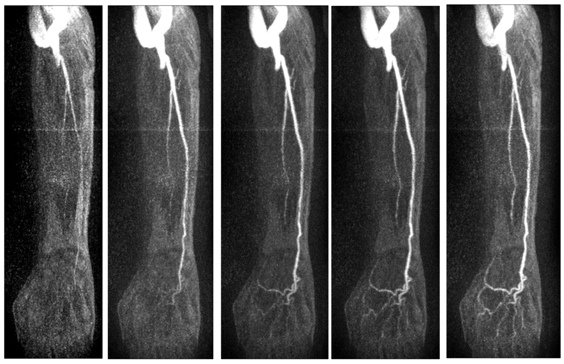


Fig. 1: Dynamic MIPs of a patient with an upper-arm shunt (left side) acquired every 2.2 s and an occlusion of the radial artery (right side).

Conclusions: We have successfully implemented a fast dynamic, contrast-enhanced MRA technique with CENTRA keyhole in clinical routine. The method combines both high spatial and temporal resolution for the diagnostics of dialysis shunts and allows assessing detailed dynamic information. We were able to demonstrate flow obstructions besides detailed vascular anatomy. The technique may help to plan adequate interventions in a high risk population. Further on it might improve the diagnostics in other high-flow vascular regions. In the future, the diagnostic accuracy should be evaluated in prospective comparative studies using DSA as the gold standard.

Reference: Hoogeveen RM et al., Proc Intl Soc Mag Reson Med. 11 (2004)