

Accelerated Functional MRI of the Bowel with a 32-Element Coil Array: Detection of Perfusion Defects Using ceMRA and DWI

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Introduction

Mesenteric ischemia is an acute disease, with fatal outcome in about 70% of the cases (1). Since the interval between the onset of symptoms and irreversible damage of the bowel is app. 120-180 min. (2), there is need for an effective and reliable diagnostic procedure which can detect early changes in the mesenteric perfusion. An early detection of acute mesenteric ischemia (AMI) requires imaging methods which are (i) sensitive to changes in the blood supply or (ii) susceptible to the net water shift associated with the development of cytotoxic edema. For this reason we studied (i) the detection of perfusion deficits in the mesenteric end-arteries using high spatial resolution contrast enhanced MRA and (ii) the detection of cytotoxic edema of the bowel wall by means of diffusion weighted (DWI) imaging. In former experiments (3) we were able to show the technical feasibility of functional MR imaging (fMRI) of the bowel with a 4-channel coil. In this study we are using a 32-channel coil array (i) to reduce image distortion and to enhance image quality in diffusion weighted (DWI) imaging and to further shorten acquisition time for MR-angiography (MRA) with the ultimate goal to improve the detection of AMI.

Methods

The mesenteric blood supply was studied in twelve healthy female pigs (weight=50kg) using a 1.5 T MR-system (Achieva 1.5, Philips, Best, The Netherlands) and a conventional X-ray fluoroscopy (DSA) located inside of the magnet room. On a floating table the pigs could be swayed between MR-scanner and fluoroscopy without changing the table. The mesenteric ischemia was induced under X-ray fluoroscopy, where a 5F Cobra-catheter was placed in the superior mesenteric artery (SMA). Through a 3F microcatheter a smaller branch of the SMA was embolized either with histoacryl to mimic an arterial embolus (6 pigs) or with particles (40-120 μm) to mimic a non-occlusive ischemia (6 pigs). Before and after (30 min, 1 h, 2 h) embolization the pigs were examined with the same protocol: To display the mesenteric perfusion a 3D-MRA sequence (FOV = (35x30x8.5) cm^3 , TE=1.7ms, TR=17ms, FA=40°) with a spatial resolution of (1x1x1) mm^3 was performed after i.v. injection of 0.2 mmol/kg body weight gadopentetate dimeglumine in coronal planes. To detect the cytotoxic edema of the bowel wall, axial diffusion weighted SE-EPI imaging (FOV = (36x36x13) cm^3 , TE=88ms, TR=4873ms, FA=90°) was conducted using b-values of 0, 250, 500 and 750 s/mm^2 . Additionally ADC-maps were calculated. For all imaging techniques used, data acquisition was performed in breath-hold mode using a 32-channel coil array (Philips Research-Europe, Hamburg, Germany). For acceleration purposes (R=5) undersampling along the phase encoding direction was placed along the L-R direction. Images were reconstructed using sensitivity encoding [4]. I.v. administration of 1.0 mg/kg body weight butylscopolamine was applied to avoid motion artifacts.

Results

After embolization with histoacryl high spatial resolution contrast enhanced 3D-MRA enabled a direct visualization of mesenteric perfusion defects as illustrated in Fig. 1. After embolization with particles no filling defect of the mesenteric branches was observed but a lack of contrast-uptake in the bowel-wall in the delayed scans was detected. DWI yielded a reduction in the water diffusion coefficient as depicted in the ADC map shown in Fig. 2. This observation was independent from the type of embolization. Compared to the results derived from studies with the 4-channel coil, the DWI image quality was found to be substantially improved. This is related to the SNR benefit of the 32-element coil array over the traditional 4-element coil. Also, by allowing faster acquisitions, parallel imaging limits image distortions due to susceptibility gradients that can degrade image quality for prolonged echo trains used in non-accelerated DWI-EPI together with the standard 4-element coil array (Fig. 1, 2). The acquisition time for high spatial resolution, large volume MRA was reduced from an impractical 52 sec to 14 sec.

Conclusion

The use of a 32-channel coil helps to improve the image quality of DWI images and to reduce the acquisition time of high spatial resolution MRA in the detection of perfusion defects after embolization of mesenteric arteries. With an accelerated imaging technique an early diagnosis of AMI becomes possible with reasonable acquisition times.

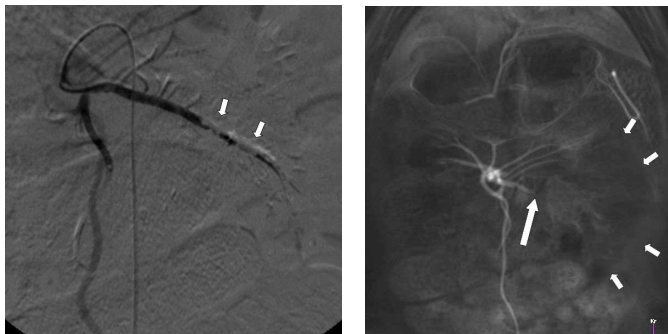


Fig 1: Conventional X-ray fluoroscopy (left) and coronal MR angiograms (right) acquired after embolization with histoacryl. The perfusion defect is clearly visible (arrows).

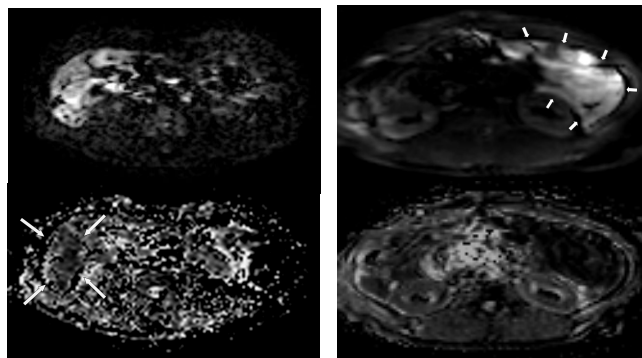


Fig 2: Axial DW- and T2-weighted images obtained with a 4-channel coil (left) and a 32-channel-coil (right). 1 h after embolization a distinct cytotoxic edema (arrows) was visible after embolization (top). The cytotoxic edema resulted in a reduction of the water diffusion coefficient as illustrated by the ADC-map (bottom).

References

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