Towards fully MR-guided TACE Procedures: Perfusion MRI and Real-time MRA Protocols

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Introduction

Transcatheter arterial chemoembolisation (TACE) in the liver plays an important role in today's management of hepatic lesions such as hepatocellular carcinomas (HCC). Unfortunately, selective and super-selective hepatic TACE can be difficult to perform under conventional X-ray imaging for several reasons: the three-dimensional extent of the embolisation volume is not easily visualized with projection imaging, and the surrounding anatomy of the liver in relation to the catheter is hardly visible in the X-ray images. During embolisation, the unwanted reflux of embolisation material is often hard to detect with X-ray imaging due to low contrast of embolisation material and low flow during the embolisation; however, it is important to define a good end point to avoid over-embolisation.

Recently, MR imaging has been used to quantify perfusion changes induced by the embolisation procedure [1]. Therefore, after placement of the catheter under X-ray guidance, baseline perfusion was quantified using transcatheter intraarterial perfusion (TRIP), the patient was re-positioned in the X-ray environment for the embolisation procedure, and finally the effect of the embolisation was quantified using a second TRIP acquisition. The aim of this experimental study was to perform an MR-guided embolisation procedure without intra-procedural patient repositioning. Therefore, after placement of the catheter under X-ray guidance, MR imaging protocols were developed and tested to perform the remaining TACE procedure fully under MR image guidance.

Methods

The MR-guided TACE procedures were performed in a clinical 1.5 T whole body MR system (Siemens Magnetom Symphony, Erlangen, Germany) equipped with an in-room monitor for real-time image display. The experiments were done in 3 healthy domestic pigs (age: 3 months, weight: 54-56 kg) under general anesthesia. Initially, a 9F introducer sheath was surgically implanted into the femoral artery of the pig. Under X-ray fluoroscopy with a mobile C-arc system, a selective 5F vertebralis catheter (Cordis) was coaxially inserted over a guidewire (Terumo) through the aorta into the hepatic artery, through which a 2F micro catheter with micro guidewire (Terumo) was superselectively positioned in the hepatic lobar or segmental hepatic artery. Once the position was reached, the guidewire was removed and the animal was transferred to the MR examination.

To assess the perfusion changes induced by the embolisation, time-resolved T1w 3D FLASH data sets were acquired before and after embolisation during the injection of a contrast agent bolus through the catheter similar to the TRIP method. For the following imaging parameters were used: TR = 2.47 ms, TE = 0.9 ms, $\alpha = 15°$, matrix = 138×192, TA/series = 4.35 s. During the image acquisition, 2 ml of a diluted contrast agent solution was injected (Gd-DTPA, Magnevist®, 1:10 in physiologic saline solution).

During the embolisation, a saturation recovery turboFLASH (SRTFL) pulse sequence was applied to monitor the distribution of the embolisation material mixed with a contrast agent with a sub-second temporal resolution. This pulse sequence uses a non-selective saturation pulse train followed by saturation recovery delay time TS and a FLASH image acquisition with centric reordering. The imaging parameters of the SRTFL were adjusted to be able to visualize a potential reflux of the embolisation material (Embosphere™, 100-300 µm) after a stasis was reached in the target tissue. The following parameters were used: TS = 40 ms, TR = 4 ms, TE = 2 ms, $\alpha = 12°$, matrix = 166×256, TA/image = 0.56 s.

Results and Discussion

In all experiments the perfusion deficits could clearly be visualized on the 3D FLASH data sets (Fig. 1). In the color-coded overlay, these defects are further pronounced. During the procedure the SRTFL could demonstrate both the wash-in of the embolisation material as well as the onset of blood flow stasis as a possible end-point of the procedure (Fig. 2). Compared to a combined X-MR procedure, which lasts about 3 h [1], the whole embolisation (after placement of the catheter still under X-ray guidance due to the lack of MR-safe guidewires) in this study could be performed in less than 30 min.

References   [1] Larson AC, et al. Radiology <u>246</u>: 964-971 (2008)
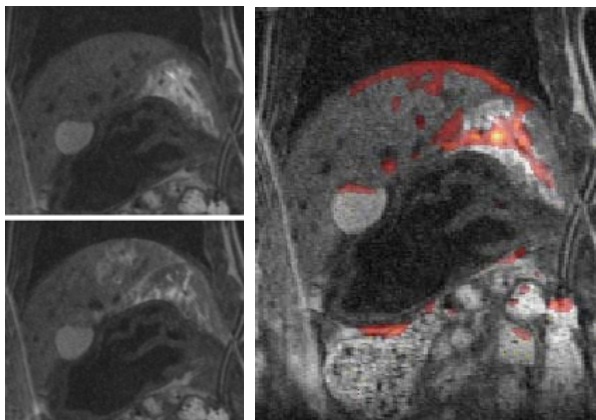
Fig. 1: FLASH images before (upper left) and after (lower left) embolisation. Perfused areas (red) after embolisation are calculated from the time-resolved MRA and are superimposed on the pre-embolisation images (right).
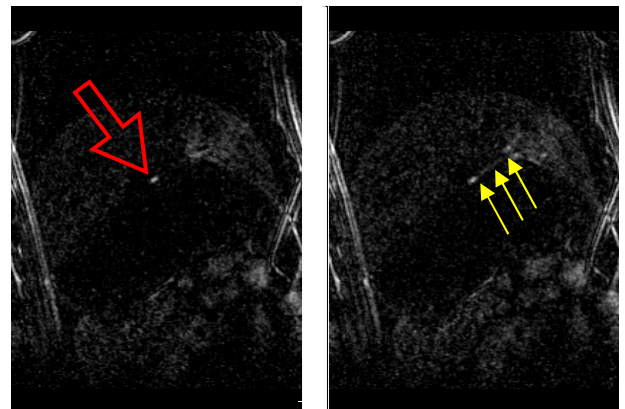
Fig. 2: Two SRTFL images acquired during the embolisation; the position of the catheter is seen as a bright spot (red arrow), and at near-stasis of the blood flow also the feeding blood vessel becomes visible.