Initial In Vivo Experience with a Novel Type of Fully MR-Safe Detachable Coils for MR-guided Embolizations

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Introduction

Since the introduction of Guglielmi detachable embolization coils (GDC) in the 1990s, their use in the minimal invasive embolization of aneurysms and arteriovenous fistulas has substantially increased. With the introduction of selective internal radiation therapy (SIRT), the pre-therapeutic embolization of the gastro-duodenal artery is more essential. The standard imaging method for these procedures is digital X-ray subtraction angiography (DSA); however, with X-ray imaging, the three-dimensional extent of the embolization volume cannot easily be assessed and the surrounding anatomy is hardly visible.

It is therefore highly desirable to perform coil embolizations under MR guidance. As conventional GDCs are made from platinum or stainless steel, they may be an MR safety hazard due to resonant device heating. MR safety issues of GDCs have been evaluated in different studies, however only in a limited number of platinum embolization coils in combination with a single MR system [1, 2]. In this experimental study a novel type of non-metallic and therefore intrinsically MR safe embolization coils is investigated in a pig model to evaluate the coils' usability for MR-guided embolization procedures.

Methods

The MR-guided coil embolization was 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. Embolization was done in a healthy domestic pig (weight: 60 kg, age: 4 months) under general anesthesia. Initially, a 9 F introducer sheath was surgically implanted into left the femoral artery. Under MR-guidance, a 5 F active tracking catheter built in-house was advanced through the aorta into the right renal artery.

To assess the renal perfusion deficit induced by the coil embolization, high resolution T1w contrast enhanced 3D FLASH data sets were acquired before and after the coil placement. Three image series were acquired in a single breath hold. After the first image series was acquired, 8 ml of a contrast agent solution (Gd-DTPA, Magnevist®, diluted 1:10 in physiologic saline solution) were injected through the catheter. The following imaging parameters were used: TR = 3.53 ms, TE = 1.2 ms, α = 23°, matrix = 448$\times$281, TA/series = 16.8 s.

To occlude the posterior branch of the renal artery, 3 polymer embolization coils (Azur Pushable, MicroVention/Terumo, Tustin, CA, USA) were injected via the catheter. The first two coils were 5 mm $\times$ 5 cm $\times$ 0,0020'' and the last coil was 5 mm $\times$ 5 cm $\times$ 0,0035''. The embolization coils were injected together with 1 ml of the same contrast agent solution. For real-time monitoring of the injection, segmented saturation recovery turboFLASH (sSRTFL) data sets were acquired which effectively eliminates background signal from non-perfused tissue. The pulse sequence uses a non-selective saturation pulse train followed by a saturation recovery delay time TS and a segmented FLASH acquisition with centric reordering. The following parameters were used: TS = 40 ms, TR = 3.6 ms, TE = 1.6 ms, α = 12°, matrix = 166 $\times$ 256, TA/image = 0.56 s. After embolization coil deployment, the high resolution T1w contrast enhanced 3D FLASH sequence was repeated every 6 minutes to assess the induced perfusion deficit.

Results and Discussion

Catheter placement and coil injection could be performed in about 30 minutes. The sSRTFL images successfully visualized the wash-in of the coil (Fig. 1). 40 minutes after embolization, the perfusion deficit could be clearly identified on the high resolution T1w 3D FLASH data sets. The color-coded overlays of different slices further pronounce the renal under-perfusion (Fig. 2).

With this initial experiment, the usability of novel, fully MR-compatible polymer coils for MR-guided embolization procedures could be demonstrated. In patient studies, however, care must be taken in terms of RF heating of the tracking catheter, e.g. by using passive catheters [3] or optical active MR probes [4].

References

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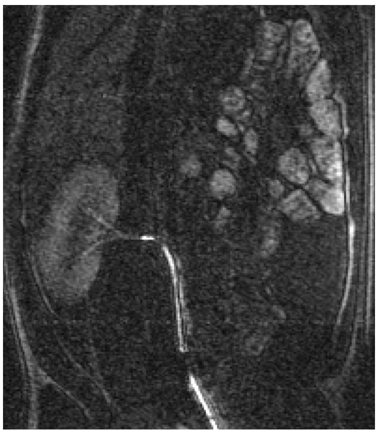

Fig.1: Real-time SSRTFL image acquired during embolization coil injection into the right renal artery.

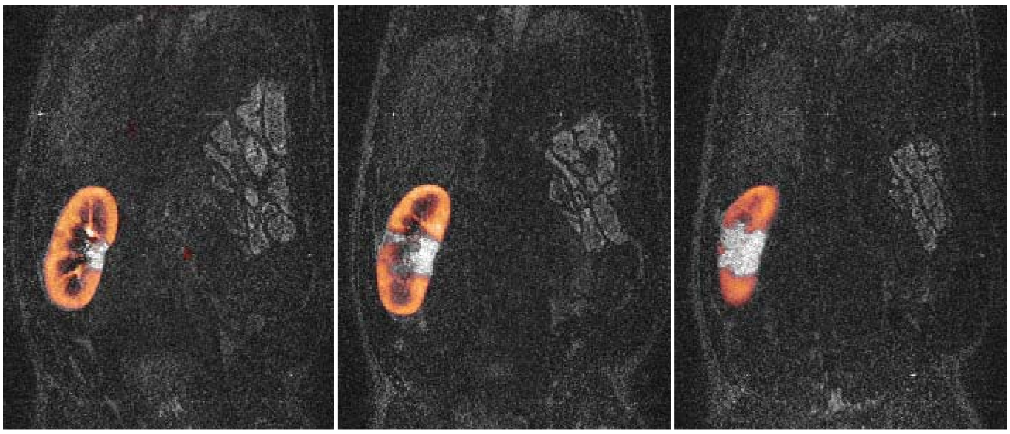

Fig. 2: Perfused areas (red) after embolization are calculated from the high resolution 3D FLASH data sets and superimposed on the pre-embolization images for 3 different slices. The reduced perfusion in the embolized areas is clearly visible.