Transition to MRI – guided interventions: First Multimodal Embolization Particles being visible in MRI and X-ray/CT

S. H. Bartling[1], J. Budjan[1], H. Aviv[2], H. J. Michaely[1], W. Semmler[3], S. O. Schönberg[1], S. Diehl[1], S. Margel[2], and M. Sadick[1]
[1]Clinical Radiology and Nuclear Medicine, University Medical Center, Mannheim, Baden-Württemberg, Germany, [2]Dept. of Chemistry, Bar-Ilan University, Ramat-Gan, Israel, [3]Dept. of Medical Physics in Radiology, German Cancer Research Center, Heidelberg, Germany

Introduction & Purpose:
Tendency exists to perform radiological interventions within a radiation-free MRI enviroment. Doing so provides several advantages including three-dimensional assessment of therapy results (1). However, there are still severe draw-backs of interventions being guided solely with MRI – which can be solved by cointegration of MRI and X-ray flouroscopy in a multimodal angiography suite.
Within interventional radiology, embolization therapy is a key procedure.
Current embolization materials are not visible (clinical) (2) or just visible within an X-ray environement (research) (3).
Particles being visible within MRI and X-ray/CT would allow direct detection in multimodal setups at all times and could therefore be beneficial to prevent miscarriage of embolization material and to assess therapy success in multimodal setups.
We developed and tested first multimodal-visible embolization particles.

Methods and Materials:
To reduce the chance of adverse reactions and to ease approval for clinical use substances have been used that are approved for clinical use and are being used on a routine-base in diagnostic imaging**.**
X-ray visible Iodine was combined with MRI visible Iron (Fe 3+) in a macroparticle (diameter 50-250µm). Its core - consisting of copolymerized monomer MAOETIB [2-methacryloyloxyethyl(2,3,5-triiodobenzoate)] - was coated with paramagnetic Iron oxide nanoparticles (USPIO, 100 nm). After ex-vivo testing, including SNR measurements (n=5), its ability to embolize tissue was tested in an established tumor embolization model in rats (n=2) and rabbits (n=5) (4).
X-ray angiography, CT and MR imaging was performed on clinical scanners (Dual-source Definition CT, 3 Tesla Magnetom Tim Trio MRI, Siemens) before, during and after application of particles to the catheterized renal artery. After positioning of the rabbits in a 12-element head matrix coil, T2w TSE images matrix (TR: 3350 msec, TE: 112 msec, slice thickness: 3 mm, pixel size 0.59 x 0.59, matrix size 256x256) were acquired before and after embolization while a EPI-sequence with a temporal resolution of 1 slice/s (coronal TR: 1330 msec, TE: 32 msec, slice thickness: 4 mm, pixel size: 1.80 x 1.80 mm, 128x104 matrix) was acquired during embolization. Histology of kidneys was prepared.

Results: The particles provided a sufficient image contrast in both CT (SNR: 14±4) and MRI (SNR: 14±1). Successful embolization of renal tissue was confirmed by particles residing within the kidney as seen in corresponding areas in MRI and CT (Figure). Echoplanar imaging during embolization provided real-time imaging of embolized kidney areas. Histology allowed a direct visualization of the residing particles as well as associated thrombosis in kidney arteries. Successful embolization was confirmed by inflammation and necrosis in treated kidneys while the control kidneys were unaltered.

Conclusion: A multimodality embolization material was successfully developed and tested in animal models. Once introduced in clincial radiology it may provide advantages in multimodal setups (as described above) and for long-time follow-up of therapy. MRI and CT could be both used to assess embolized tumor areas and could refine and improve embolization therapy.

References:
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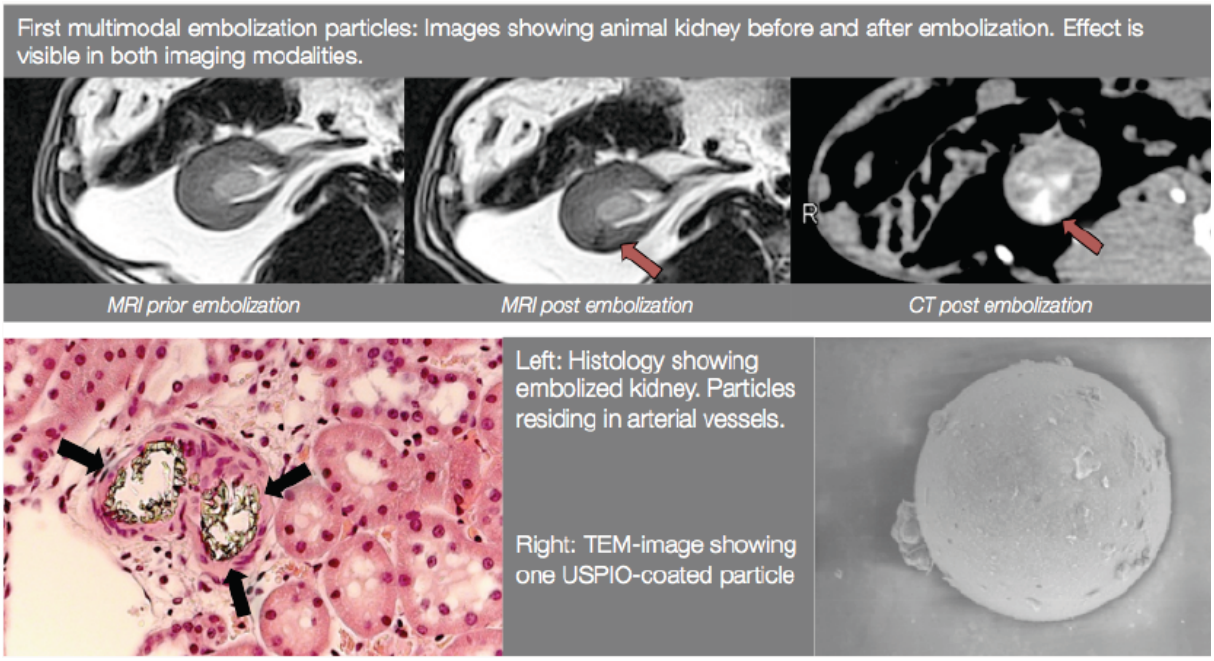

Figure: Demonstration of first multi-modality embolization particles by in-vivo MRI, CT, histology and ex-vivo transmission electron microscopy (TEM).