# Multinuclear ($^{19}$F + $^{1}$H) high-resolution intravascular MRI of perfluorooctyl bromide (PFOB) microcapsules at 3T

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**Audience:** MR Interventionalists interested in cellular therapeutic delivery or vulnerable plaque detection.

**Purpose**: One of the challenges in the development of transplanted cellular therapeutic strategies is effective *in vivo* tracking of cells post-delivery. Fluorine ($^{19}$F) MRI combined with anatomic proton ($^{1}$H) MRI provides an effective method for tracking labeled cells[1]. Conventionally, surface and/or body radiofrequency coils have been utilized for the MRI component of such multimodal imaging. Recently, 3T intravascular MRI (IVMRI) probes have been shown to provide high-resolution *in vivo* trans-luminal imaging with local signal-to-noise ratios superior to surface coils[2]. Here, for the first time, using an IVMRI probe designed for both $^{1}$H and $^{19}$F MRI, we show high-resolution localization of perfluorooctyl bromide (PFOB) microcapsules in a porcine heart *ex vivo*. Localization is confirmed by computed tomography (CT) imaging of the microcapsules.

**Methods**: A multinuclear IVMRI probe was designed using a 2mm outer-diameter 3T loopless antenna with a 40mm resonant whip. The whip length was essentially the same at the proton and fluorine Larmor frequencies (128,116MHz)[3], thereby allowing interchangeable operation for both nuclei. A switchable interface afforded either transmit/receive or receive-only operation[2]. The probe was inserted into an *ex vivo* porcine heart immersed in body-equivalent (3gL$^{-1}$) saline and the ventricle was accessed via the brachiocephalic artery. PFOB microcapsules were produced using a modified alginate microencapsulation method with the addition of 12% (v/v) PFOB allowing for multimodality (MRI + CT) detection. Approximately 0.8cc of PFOB capsules was injected into the tissue between the brachiocephalic and subclavian arteries (Fig. 1a). The same IVMRI probe was used as: (1) a receiver with body-coil transmission for $^{1}$H MRI on a Philips 3T (Achieva); and (2) in the transmit/receive mode for $^{19}$F MRI on a Siemens 3T (Tim Trio). The proton and fluorine images were co-registered and overlaid to form a composite image. MRI was followed by c-arm CT imaging (Artis Zee, Siemens) to confirm the deposition of the radio-opaque microcapsules.

**Results**: Insertion of the probe into the heart can be seen under $^{1}$H MRI (bright line, Fig.1a). PFOB capsules are identified under $^{19}$F MRI at 0.8mm in-plane resolution (Fig. 1b, magenta). $^{1}$H IVMRI at 0.2mm resolution clearly delineates the vessel wall (around *p*, Fig. 1b). The composite image (Fig. 1b) shows good correlation with a CT cross-sectional reformat at the same location (Figs. 1c, 1d).

**Conclusions**: We show, for the first time, that 3T IV MRI detectors are ideally suited to high-resolution (sub-mm) detection of both fluorine and hydrogen. Multinuclear IVMRI probes provide an effective method to image and monitor potential cardiovascular labeled cellular therapies *in vivo*.

***Refs***: **(1)** Barnett BP, et al. Radiology. 2011;258(1):182-91 **(2)** Sathyanarayana S, et. al., JACC Card Im. 2010; 3:1158-1165. **(3)** El-Sharkawy AM et al. Med Phys 2008; 35:1995-2006.

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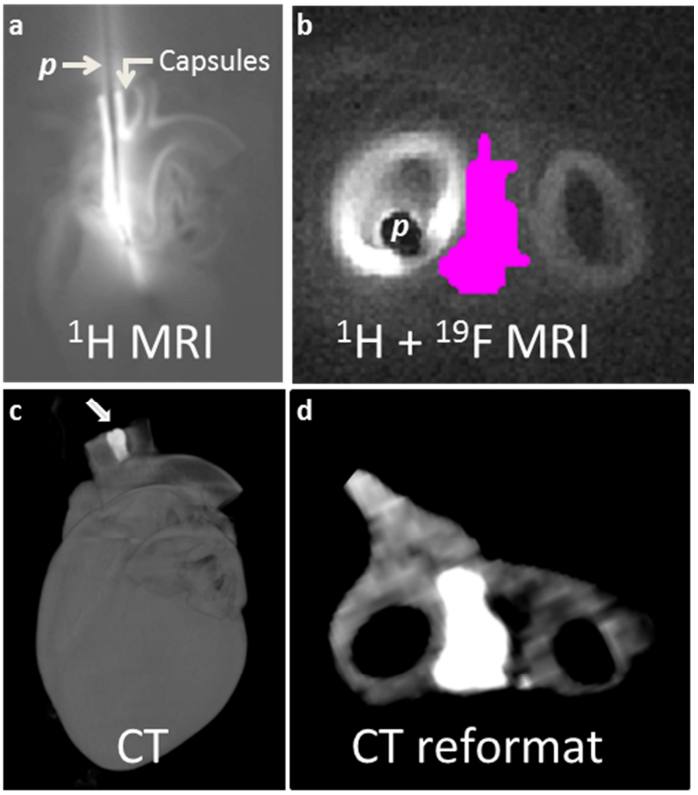


**Figure 1**: **(a)** Proton MRI from an intravascular probe *p* inserted into a porcine heart *ex vivo* showing location of PFOB capsules injection. **(b)** Composite image showing Fluorine MRI from the same probe at the injection site overlaid (magenta) on a proton MRI of the vessel. ($^{1}$H MRI: 3D TSE, TR/TE=298/14ms, FA=90°, voxel =0.2×0.2×4mm$^{3}$, TSE fact. 6; $^{19}$F MRI: 3D TruFISP, TR/TE= 4/2ms, FA=12°, voxel =0.8×0.8×5mm$^{3}$, 32 avg.) **(c)** CT of the whole organ (70kV, 20sDCT) confirms location of the radio-opaque capsules (arrow) and **(d)** reformatted CT images at the injection location shows high correlation with (b).