Transendocardial therapeutic-delivery using real-time MRI guidance

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Audience: Interventionalists and clinicians interested in minimally invasive therapy delivery.

Background: Catheter-based transendocardial injection offers a minimally invasive method to deliver therapeutics to the heart, but conventional X-ray fluoroscopic guidance suffers from poor demarcation of myocardial boundaries and an inability to assess myocardial viability. MRI-guided delivery of therapeutics at 3T offers the potential for more precise therapeutic targeting with superior tissue contrast. We demonstrate transendocardial injection of a prototype therapeutic into the myocardium of a normal swine using real-time MR guidance and a custom active injection catheter.

Methods: A custom, MR- trackable, steerable transendocardial injection catheter (10F diameter, 135 cm long) with four built-in active tracking coils (Fig. 1a) was visualized and tracked using the Interactive Front End (IFE) navigation software in conjunction with a real-time tip-tracking sequence (BEAT_IRTTT[1]) running on a Siemens 3T system. The catheter model was built using *a priori* knowledge and real-time coordinates of the tracking coils (Fig. 1b). Three-dimensional (3D) surfaces of the heart chambers (LV, RV) and infarct region were constructed from a breath-hold, multi-slice cine short-axis stack and overlaid within IFE (Fig. 1c). In addition, the distal tracking coil could be used for high resolution myocardial wall visualization, exemplified *ex-vivo* (Fig 1d). Using real-time model guidance, the catheter was navigated to target injection sites and using a nitinol needle, iron oxide-impregnated alginate microbeads (50 µm diameter, 0.02 mL/injection) were injected into the myocardium. Injections were visualized in real-time (Fig 1e) and delivery success was confirmed using a breath-hold, multi-slice sequence (Fig. 1 f,g) .

Results: Left ventricular catheterization and guidance to four target sites in the myocardium was achieved. Confirmation of microbead delivery was possible, but difficult due to the small volume delivered. A potential advantage of the current system is the ability to direct the injection catheter towards the myocardial wall prior to therapeutic injections (Fig. 1d).

Conclusion: A real-time interface with active catheter tip tracking enabled successful 3T MRI-guided transendocardial delivery of a prototype therapeutic to the *in vivo* heart.

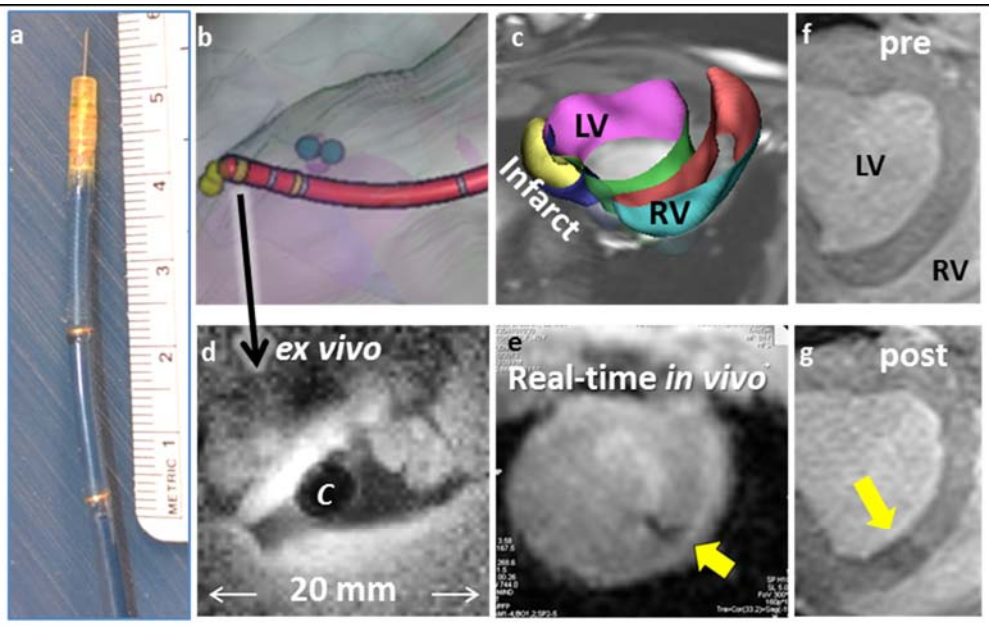

Fig.1 (a) Needle catheter with microcoils and extended nitinol injection needle. **(b)** Catheter model overlaid within IFE. **(c)** 3D model of target regions overlaid on real-time images. **(d)** *ex vivo* ventricle image from tracking coil *c* (2D GRE, TR/TE =200/4ms,voxel=0.5×0.5×5mm^3) (**e**) Real-time *in vivo* monitoring of iron oxide-impregnated therapeutic injection into myocardium (arrow). TruFISP real-time images, TR/TE=2.8/1.19 ms, voxel= 1.9x1.9x5mm^3, FA/tracking FA =50^o /15^o, 1.5-4 frames/s. **(f, g)** Pre- and post-injection MRI *in vivo* confirms injection of microbeads. Multi-slice 2D FLASH, TR /TE = 6.8/3.25ms, FA=30^o, voxel =1.0×1.0×5.0mm^3.

Reference: **(1)** Pan L. et.al, ISMRM 2011, pp. 195. Support: 2011-MSCRFII-0043, Siemens Corporation