Development of an Interventional Endo-MRI: Toward the Therapy of Pancreaticobiliary Diseases

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Introduction:

Over the last few decades, endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic ultrasound (EUS) have played key roles in interventional therapies of pancreaticobiliary diseases, such as sphincterotomy, stone extraction, stricture dilation, stent placement, tissue sampling, pseudocyst drainage, and drug delivery (1-3). Magnetic resonance imaging (MRI), which provides excellent soft-tissue contrast as well as 2D/3D high resolution imaging, may potentially be a useful imaging tool to monitor interventions for various medical applications. In this study, we attempted to develop an interventional endo-MRI, which is specifically designed for potential treatments of pancreatic and biliary diseases.

Materials and methods:

Similar to an endoscope-based ultrasound, an endo-MRI coil was designed as a saddle and mounted onto the distal tip of a plastic tube, in which an instrument channel is typically used for delivering endoscopic accessories, such as biopsy or injection needles. The outlet of the instrument channel was built within the center of the MRI coil, which thereby allowed the coil to generate high quality MR imaging to guide needle placement or other therapeutic procedures (Figure 1). The coil was tuned to 64MHz with a matching/decoupling circuit, and then connected to a 50Ω coaxial cable through a balun. To test the possibility of generating MR imaging using this endo-MRI coil, we set up an in vitro experiment by using a cylindrical water phantom with a tube in its center. Through the tube, the coil was placed into the center of the phantom and connected to a 1.5T MRI scanner (GE Healthcare, WI, USA). We then obtained a T1-weighted imaging using spin echo pulse sequence (TR/TE=500ms/11ms, Thickness=5mm, NEX=2, FOV=18x18cm and Matrix=256x256) and T2-imaging using fast spin echo pulse sequence (TR/TE=2000ms/102ms Thickness=5mm, ETL=12, NEX=2, FOV=18x18cm and Matrix=256x256). To initially test the feasibility of using endo-MRI to guide the placement of a fine needle, we then performed an ex vivo experiment. The endo-MRI coil was placed into a portal vein of a pig liver and connected to the MRI scanner. The MR imaging was obtained by using FSPGR pulse sequence (TR/TE/FA=34ms/5.9ms/20^{o}, Thickness=3mm, NEX=1, FOV=16x16cm and Matrix=256x256). Under MR imaging, an 18G needle was then punctured into the liver through the instrument channel of the endo-MRI coil. To compare endo-MRI with endoscopic ultrasound, we subsequently repeated the exact same ex vivo experiment of the needle placement as we performed with endo-MRI, but guided by endoscopic ultrasound (EU-C60, 7.5MHz, Olympus, PA, USA).

Results:

Figure 2 shows the high resolution and high signal-to-noise ratio MR imaging using the endo-MRI coil. The ex vivo fine needle placement under MRI and ultrasound imaging are shown in Figure 3. Imaging of the needle was clearer with MR imaging than with US imaging.

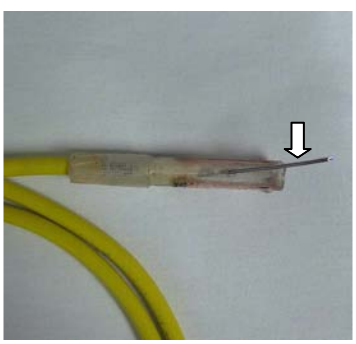

Figure 1. Endo-MRI coil. The outlet of the instrument channel was built within the center of the MRI coil. The arrow shows the fine needle.

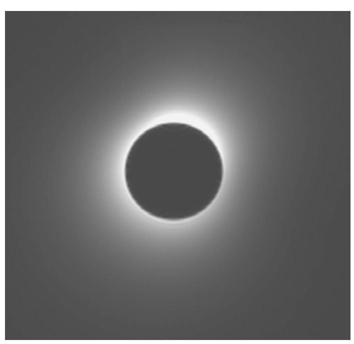

Figure 2. T1-weighted imaging of water phantom using endoscopic MRI coil. The MR imaging parameters:TR/TE=500ms/11ms Thk=5mm,NEX=2,FOV=18x18 cm, Matrix=256x 256.

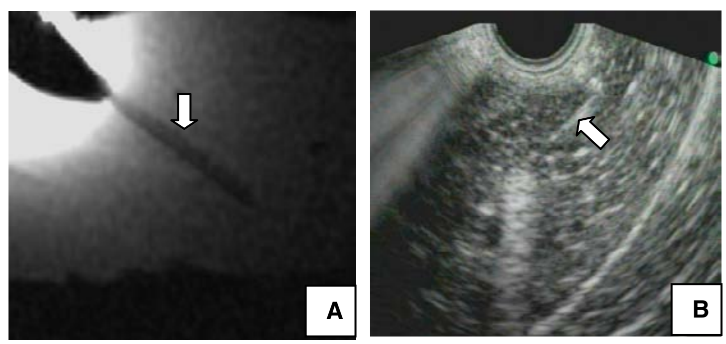

Figure 3. (A) Endo-MR imaging of fine needle placement in a liver ex vivo (FSPGR, TR/TE/FA=34ms/5.6ms/20^{o}, Thk=3mm, Fov=16x16cm, Nex=1). The solid arrow indicates the fine needle on the imaging. (b) Endoscopic US guiding the needle placement in the liver (the arrow shows the fine needle).

Conclusion: This study has initially shown that the endo-MRI can provide higher resolution and high quality imaging for guiding needle placement compared to endoscopic ultrasound imaging. Since MRI also offers great soft-tissue contrast and 3D high resolution imaging, endo-MRI may provide significant advantages over endoscopic ultrasound to guide pancreaticobiliary intervention.

Reference:

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