IMAGING OF ANATOMICAL STRUCTURE AND BLOOD VESSELS IN PORCINE GASTRIC WALL BY MR ENDOSCOPE

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Introduction

The final goal of this study is to establish an MR endoscope system, which can implement MR imaging and endoscopy simultaneously and provide MR images superimposed on the scope view as the navigation [1]. MRI depicts the anatomical structure and the soft tissue with high contrast which is one of the disadvantages of ultrasound, for example, ultrasound endoscope. Endoscope has been a useful and practical instrument, but has difficulty in finding the depth of tumor infiltration. An MR endoscope could resolve the disadvantages of an endoscope and help diagnose precisely and also carry out secure endoscopic surgery. This paper focuses on imaging the anatomical structure and blood vessels in the gastric wall in an in vivo animal experiment, to help perform endoscopic submucosal dissection (ESD) safely, which has a difficulty in identifying the vascularity within the submucosa and muscularis layers in the gastric wall.

Materials and Methods

Swine, which weighed 30 to 40 kg and were controlled for animal study, were used as the subjects. This study was approved by the Animal Experiment Committee at our institute. The intracavitary RF coil with an active decoupling circuit [2] was designed as 2-turn surface coil with 40 mm × 50 mm size (Fig. 1). The coil was composed of copper with a width of 2 mm and a thickness of 0.035 mm, and also equipped with fixation parts on the gastric surface. The frequency and the impedance of the coil were adjusted to the MR scanner (Signa EXCITE Twin Speed 1.5T ver.11, GE Healthcare, Milwaukee, WI, USA). The coil element was rigidly wrapped with polyimide substrate with a thickness of 0.025 mm, and every electrical part was covered with silicone to avoid electrical leakage. In addition, about 5 mm cubic substances, which included 5 mM Gd and were covered rigidly with cling film and silicone, were placed on the coil as the marker for MRI. A coaxial cable (0.8D2V) made of nonmagnetic material was used. To insert the coil perorally, the coil should be furled, and then inserted using an endoscope (GIF-H260Z, Olympus, Japan). The fixation of the coil in the gastric cavity was performed by clamping the fixation part of the coil on the mucosa with the endoscopic tools (Fig. 2). After the fixation and the endoscopic video recording, the endoscope was removed, and MR imaging was executed using the following sequences: (1) to identify the coil in the gastric cavity, Fast Spin Echo (FSE) with TR, 300 ms; TE, 14.4 ms; ET, 6; slice thickness, 5 mm; (2) to take the anatomical images of the gastric wall, FSE with TR, 300 ms; TE, 14.2 ms; ET, 4; signal acquisition, 6 as T1W image, and TR, 2000 ms; TE, 85.2 ms; ET, 32 as T2W image; and (3) to image blood vessels in the gastric wall, 3D Fast Spoiled Grass (FSPGR) with TR, 10.7 ms; TE, 3.9 ms; Flip Angle, 15 degree; signal acquisition, 1 as dynamic MR angiography (DMRA). The spatial resolution was 0.156 × 0.156 × 5 mm. Breath holding by the respirator was executed during anatomical imaging. To clearly obtain blood vessels in the submucosa and muscularis layers, hyaluronic acid sodium diluted 4 times with physiological saline was injected into the submucosa. An MR contrast agent (Magnevist, Schering) was injected intravenously 10 seconds after the MR scan started, and then the breath holding was applied 20 seconds after the scan started. The scanning time for the blood vessel imaging was about 98 seconds. The animal experiments were performed while the swine were under general anesthesia.

Results

The Q factor of the coil was about 37 at loaded and about 75 at unloaded. The coil location at MR images could be identified definitely with Gd markers; therefore, the slice locations for the anatomical and blood vessels imaging were determined precisely and easily. Four or five layers in the gastric wall, which might be mucosa (epithelium and/or muscularis mucosae), submucosa, muscularis, and serosa, could be distinguished with the anatomical image (Fig. 3). The SNR of mucosa (or submucosa), muscularis, and serosa were about 57, 39, and 55 in the T1W image, and about 88, 22, and 80 in the T2W image, respectively. Theoretically, the surface coil has a valuable SNR region within the radius of the coil structure. The coil was placed on the stomach surface; accordingly, the outer region of the stomach, for example, the gallbladder, liver, and small intestine, was depicted. The enlarged submucosa, by injecting hyaluronic acid sodium, was also depicted in T1W and T2W images, and then the blood vessels in the submucosa and muscularis layers were definitely depicted with DMRA (Fig. 4). The vascularity was clearly visualized 20 to 30 seconds later after the contrast agent was injected. A time resolution of 14 sec/phase for DMRA should be required to obtain a higher quality image, but it would be possible to improve the time resolution and the scanning time. The visualized vascular size was a thickness of about 1 mm in the image, which could be sufficient to support ESD. The motion artifact due to aorta and cardiac beating appeared, but it was not very critical problem to identify the anatomical structure and blood vessels in the images shown in Fig. 3 and Fig. 4.

Conclusion

The ability to depict the anatomical structure and blood vessels in the gastric wall using an MR endoscope was demonstrated in an in vivo experiment. An MR endoscope would be used to image the other intraperitoneal organ by adjusting the intracavitary coil structure. The problems need to be resolved are the alleviation of the motion artifact, the reduction of the scanning time, and the bio-safety about the coil. And also optimizing the coil structure and miniaturizing the coil circuit are an important matter. The MR endoscope system with a navigation component would be an useful practical application system.

Acknowledgment

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References

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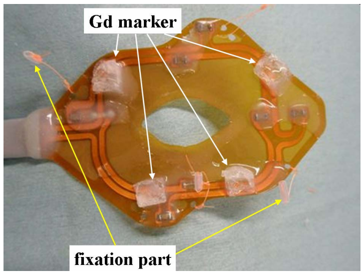

Fig.1 Intracavitary RF coil with Gd marker and the fixation parts.

Fig.2 Endoscopic view of the gastric cavity in which the coil was fixed.

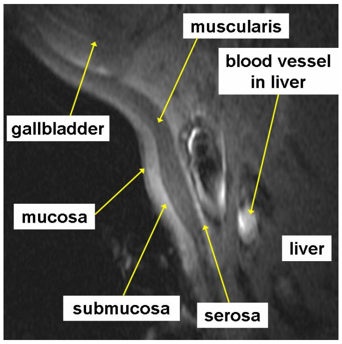

Fig.3 Gastric wall structure and outer region were depicted with a T1W image.

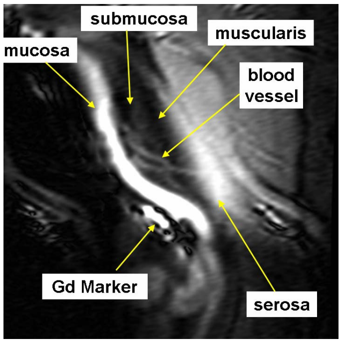

Fig.4 Blood vessel in submucosa and muscularis was visualized by DMRA.