Spatio-temporal analysis of antral peristaltic contractions using MRI

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Introduction

The use of MRI to study gastric motor function is limited and has mostly concentrated on quantifying volumes during gastric emptying [1]. Other important determinates of gastric motor function such as the velocity, frequency, and direction of antral peristaltic contractions have been more difficult to measure due to temporal undersampling and diaphragmatic distortion issues. We have developed MR image acquisition and data analysis methods to better ascertain how propagating antral contractions affect gastric emptying in health and disease.

Methods

Imaging studies were performed at 3 Tesla Trio and Verio MRI scanner (Siemens Healthcare, Erlangen, Germany) using 32-channel cardiac coil (RAPID MR International, Columbus, OH). Four dogs, one pig, and two healthy human volunteers were imaged according to protocols approved by the local IRB and IACUC. The animals were fasted prior to imaging and sedation level was adjusted during imaging session to the lowest acceptable level to restore gastric motor functions.

SSFP pulse sequence was selected for this study due to high tissue-fluid contrast, fast scan time, and high SNR. Local shimming for the region of interest (ROI) and frequency scout were performed to minimize off-resonance artifacts in the ROI. Imaging of gastric motor functions was performed using 2D SSFP sequence with the following scan parameters: TR/TE=2.8/1.5 ms, flip angle of 35^o, pixel size=1.25x1.25 mm, slice thickness of 3 mm, GRAPPA with R=3, temporal resolution from 220 to 340 ms depending on the required FOV.

The stomachs of two fasted healthy human volunteers were determined using localizer scans, then the subjects were given 400 mL of body temperature water to dilate the stomach. A suitable imaging plane was then chosen that revealed the lesser and greater curvatures in the corpus and antrum of the stomach (Fig. 1A). A similar procedure was used to locate the stomach in anesthetized animals. To examine the stability of antral peristaltic contractions, subjects were scanned for 10-16 minutes at high spatial and temporal resolution in fasted conditions or after solid or liquid meals. Diaphragmatic distortions were corrected using highest probability tracking algorithms, then the wall of the stomach at the lesser and greater curvatures were tracked. Diameters were calculated between the curvatures to construct spatio-temporal (ST) maps (Figs. 1B, 2A) from which frequency, velocity, coherence (Δ velocity), and direction were calculated. In some recordings from human subjects, air remained trapped in the ventral portion of the stomach, providing high contrast movies from which the outline of the lumen could be rendered over time as a 3 dimensional object (Figure 2 B-D).

Results

Good quality data were obtained in three dog studies and all human volunteers studies. Gastric motion was no observed in one dog and one pig studies despite of reduction of sedation level to the minimal acceptable level. Initial analysis of the acquired images show the developed imaging technique has adequate spatial and temporal resolution to characterize important determinates of gastric motor function such as the velocity, frequency, and direction of antral peristaltic contractions. Preliminary results show that variations in the frequency, velocity and amplitude of antral peristaltic contractions are a relatively common occurrence in dogs (Fig. 1) and humans (data not shown). Further studies are planned to better distinguish between patterns of antral contractility in disease states such as functional dyspepsia and gastroparesis.

Discussion and Conclusion

Spatio-temporal mapping of antral peristaltic contractions in the stomach using MRI provides high resolution images from which most parameters of gastric motion can be accurately quantified. The developed imaging method is far superior to traditional measures of gastric motor activity (EGG & manometry) and has revealed various patterns of gastric motor responses that may correspond to different rates of gastric mixing and emptying.

Acknowledgments: This study was supported in part by NCRR (5P20RR018751-09) and NIGMS (8 P20 GM103513-09).

References: [1] Fruehauf H, et al., Neurogastroenterol Motil 2009; 21:697-e37.

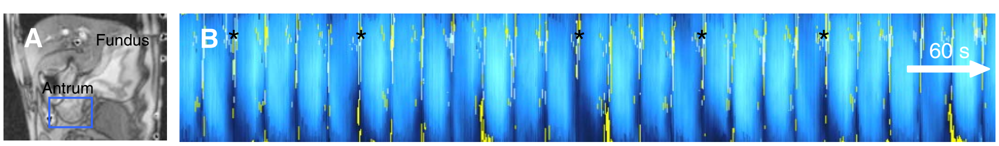

Figure 1. Spatio-temporal map of variable occurrence of large (*) and small amplitude contractions (**B**) in the canine gastric antrum (**A**).

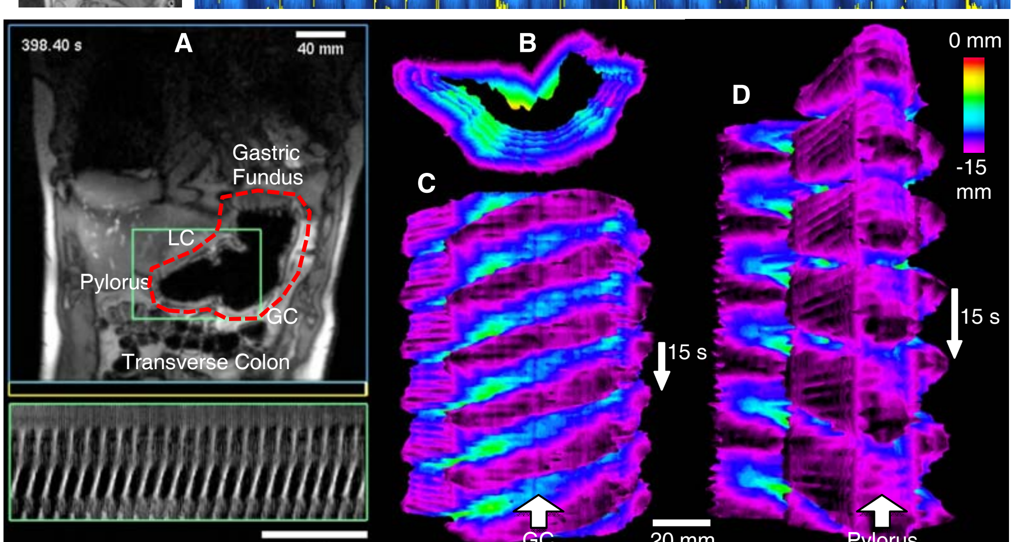

Figure 2. Spatio-temporal analysis of human antral peristalisis.
(**A**) shows coronal view of abdomen (stomach - red outline; LC = lesser curvature, GC = greater curvature). ST Map at bottom shows the frequency and velocity of antral peristaltic contractions.
Rendering the stomach outline over time: (**B**) view point down time [Z]-axis) as 3D ST cubes shows the propagating contractions in the context of the shape of the stomach and allows more precise measurements of propagation: (**C**) view point GC; (**D**): view point Pylorus.