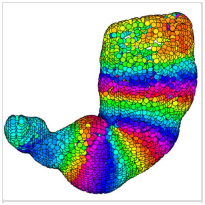

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4D Upper Gastrointestinal Magnetic Resonance Imaging in Healthy Human Subjects and Gastroparetic Patients

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This protocol described the steps to acquire and analyze 4D gastric magnetic resonance imaging data under fast and fed states in healthy human subjects and patients with gastroparesis.

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gastric MRI, human, gastroparesis, gastric emptying, gastric motility

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Subjects

1 Twenty healthy subjects (14 females; 6 males) and 15 gastroparetic patients (11 females; 4 males) participated in this study under research protocols approved by the Institutional Review Board at Purdue University and Indiana University School of Medicine. All healthy subjects did not have a prior diagnosis of neurological, psychiatric, or gastrointestinal (GI) disorders. All gastroparetic patients had documented delayed gastric emptying by a standardized 4-h gastric emptying scintigraphy test (Tougas et al., 2000). Written informed consent was obtained from all participants. Standard MRI exclusion criteria were applied.

Experiment design

2 Subjects were studied using a 3T Siemens Prisma MRI scanner in the morning after a 12-h overnight fast. During the fast, subjects were asked to avoid any alcohol, caffeine, or medication that could affect GI function. The study began with a baseline 3D T2-weighted MRI scan to ensure the subject had a fasted stomach. This was done by checking the resting stomach did not contain any residual food but only the gastric juice, which appeared bright in T2-weighted images. The resting gastric juice was later manually segmented and its volume was calculated for each subject. Then, the subject was given a naturalistic contrast meal consisting of 350g blended natural ingredients that were rich in manganese content (128g firm tofu, 95g pineapple chunks, 57g pineapple juice, 32g blueberry, and 38g banana). The nutrient content of this test meal was as follows: energy (kcal) 236, carbohydrate 74%, protein 13%, fat 7%, and fiber 6%. Immediately after meal, a set of three-dimensional (3D) T1-weighted dynamic MRI scans were acquired for about 5 minutes. Each scan consisted of 60-80 coronal image slices covering the entire stomach with an isotropic spatial resolution of 1.9 mm. The sampling interval between MRI volumes was 3.3-4.2s. The same set of scans was repeatedly performed approximately every 10 minutes for 1-hour post-meal.

MRI acquisition and analysis

3 The MRI scans were performed using a 3T Siemens Prisma MRI scanner with an 18-channel body coil, a 32-channel spine coil, and conventional 3D imaging sequences. The baseline MRI scan was performed using a 3D true fast imaging with steady-state free precession sequence (TRUFI) under free-breathing (repetition time (TR) = 372.7ms; echo time (TE) = 1.85ms; flip angle (FA) = 57^{o}; field-of-view (FOV) = 340×340mm; in-plane resolution = 0.7×0.7mm; 20 coronal slices; slice thickness = 6mm; GRAPPA = 4). Post-meal MRI scans were performed using a 3D Spoiled Gradient Echo Variant sequence (VIBE) under free-breathing (TR = 3.62ms; TE = 1.23ms; FA = 12^{o}; FOV = 360×360mm; in-plane resolution = 1.9×1.9mm; 60 coronal slices; slice thickness = 1.9mm; CAIPIRINHA = 5; partial Fourier factor = 7/8; acquisition time per volume = 3.3-4.2s; 100 volumes were acquired in each scan session). Note that some subjects had their stomach distended more along the posterior-anterior direction. To cover the whole stomach in those subjects, 80 coronal slices were prescribed and thus the acquisition time increased to 4.2s per volume accordingly. The analysis of gastric emptying and motility is described in Lu et al., Neurogastroenterology & Motility, 2021.

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