Magnetic Resonance Imaging to investigate the influence of posture on gastric physiology

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Synopsis
In this study, the influence of posture on the physiology of the human stomach was analyzed using a compact 1.5T MR system and a 0.5T open MR system. A method for the detection of gastric function during one imaging session and using different MR system was developed and evaluated in volunteers. Gastric emptying, motility were similar in seated and right decubitus body position. However, differences in gastric relaxation and retained intragastric air volume were observed. The data suggest that posture has effects on gastric physiology. Measured data in lying position from compact MR systems must be interpreted with caution.

Introduction
The influence of posture on the physiology of the human stomach has so far been analyzed exclusively using γ-scintigraphy. This technique exposes volunteers repeatedly to ionizing radiation and suffers from poor temporal and three dimensional spatial image resolution. MRI has been shown to detect reliably gastric emptying, motility and intragastric distribution of meal components. However, modern high performance MR systems only permit imaging in the lying position. The use of an open configuration MR system permits imaging in seated body position and therewith the assessment of differences in gastric function dependent on posture. This allows a critical interpretation of physiological data acquired in lying position. In this study we developed and evaluated a method to assess gastric emptying, relaxation, motility and intragastric distribution in a single imaging session on two different MR systems.

Methods
In this pilot study gastric function was monitored in sitting position (SP) using a 0.5T open MR system and in right decubitus position (RDP) using a 1.5T compact MR system. Three volunteers were imaged in SP and RDP on two different days. A low fat mixed solid/liquid meal was administered to the subjects consisting of 150 g pasta (252 kcal; protein: 9 g; carbohydrates: 39 g; fat: 2.25 g) and 150 ml nutrient drink (225 kcal; protein: 9 g; carbohydrates: 30 g; fat: 7 g). The liquid meal was labeled with 0.1% of Gd-DOTA (DOTAREM®, Laboratoire Guerbet, France) and given after the ingestion of the solid meal. The solid meal was always ingested in the seated position however the liquid was given either in SP or RDP according to the MR system architecture. A scan covering the gastric region (volume scan) was performed in fast state and after solid meal intake (t = 0 min). After drinking, a volume scan followed by a dynamic scan sequence (motility scan) was performed in 5 min intervals until t = 30 min and thereafter in 10 min intervals until t = 80 min. In the open MR system (Signa SP/i 0.5 T, GE Medical Systems, Milwaukee, WI, USA) an abdominal surface coil was used; images were acquired with a fast spoiled gradient echo (FSPGR) sequence (volume scan: 20 sagittal slices, Tscan = 44 s, 2 breathholds, TR/TE = 150/8 ms; motility scan: 70 oblique coronal dynamics, Tscan = 148 s, TR/TE = 17/8 ms). In the 1.5T compact MR system (1.5 T Intera, Philips Medical Systems, Best, The Netherlands) six coil elements were positioned around the abdomen and a steady state free precession (SSFP) sequence was applied (volume scan: 3 image stacks with 20 sagittal, 12 transversal, 12 coronal images, Tscan = 28 s, TR/TE = 4.0/1.8 ms; motility scan: 3 parallel oblique stacks each 115 dynamics (interleaved), Tscan=167 s, TR/TE = 4.0/1.8 ms, SENSE factor = 1.5). Images of volume scans were intensity corrected. Stomach and meal volume as well as intragastric distribution of the marked liquid meal were determined from volume scan data. The stomach volume was segmented and total meal and fluid volume were determined by applying different intensity thresholds (Fig. 1). Gastric contraction frequency and velocity were extracted from the images of a motility scan by detecting the gastric contraction waves along a predefined gastric axis (Fig. 2). The small number of volunteers precluded formal statistical analysis. Therefore, only descriptive comparison of the differences in gastric function between SP and RDP is given here.

Results
Gastric emptying, relaxation, motility and intragastric distribution could simultaneously be monitored during a single MR imaging session. The method was successfully applied in two different MR systems. No difference in gastric emptying was observed between the SP and RDP (AUC at t = 80 min: SP, 78 % ± 7 %; RDP, 81 % ± 6%). Increasing divergence of the two emptying curves was observed from t = 60 – 80 min (Fig. 3). The data suggest that posture has effects on gastric physiology. Postprandial gastric relaxation was reduced and retention of air in the stomach was increased in the RDP in all volunteers studied. Effects on gastric emptying may also be present. In contrast, gastric motility was not affected by posture. In conclusion, measurements of gastric physiology performed in lying position in compact clinical MR systems must be interpreted with caution.

Discussion
We have confirmed the feasibility of simultaneous measurement of gastric emptying, relaxation and motility using MRI. We have been able to show the separate emptying of the liquid and solid phases using Gd-DOTA as a liquid nutrient marker. This preliminary data suggest that posture has effects on gastric physiology. Post-prandial gastric relaxation was reduced and retention of air in the stomach was increased in the RDP in all volunteers studied. Effects on gastric emptying may also be present. In contrast, gastric motility was not effected by posture. In conclusion, measurements of gastric physiology performed in lying position in compact clinical MR systems must be interpreted with caution.