# Non-Invasive MRI-based 3D Volumetric Serial Assessments of Physiologic Large Intestine Gas - Proof of Principle

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**Introduction** Various approaches have been considered in estimating physiologic bowel gas volume and normal ranges in healthy subjects, including direct gas capture, computed tomography, plain-film radiography, and ultrasound[1]. This study examines the utility of a non-invasive single-shot MRI technique without bowel preparation, anti peristaltic drugs, or exogenous contrast (water, air or Gadolinium-based contrast agents), to provide a 3D dataset that may be semi-automatically segmented for determination of large bowel gas volume.

**Materials and Methods** Five healthy female subjects were recruited for serial imaging of the abdomen. A standardized diet was initiated on Day 0 and 6 scans (8:30 am, 11 am, 1 pm) were acquired over the next two days while maintaining the standardized diet. Informed written consent was obtained as approved by the University of Western Ontario HSREB. On Day 2, subjects were administered a bowel challenge in the form of lactulose(25 mg). Following each scanning session subjects subjectively reported upon their gastrointestinal comfort (GI questionnaire).

Imaging was performed on a Siemens 3.0T Verio scanner using combinations of Siemens spine array, flex body array, and large flex array receiver coils. All subjects were scanned in the prone position with breath-hold imaging performed upon exhalation. Three-plane gradient echo scout images were acquired at 3 table positions with overlapping fields-of-view to create composite reference images for purposes of axial slice planning and receiver coil activation. An axial interleaved single shot HASTE breath-hold acquired in isocenter mode at 3 table positions was used to obtain the required images. The images were organized into a series of 99 contiguous slices for anatomical coverage inferiorly to include all of the rectum, and superiorly to include some of diaphragm (FOV = 37cm, voxel size = 1.4 x 1.4 x 3.0mm, matrix 256 x 256, phase partial Fourier 5/8, acceleration factor GRAPPA 2, TE = 68ms, Bandwidth =781 Hz/Pixel, acquisition time per slice = 1s). Coronal HASTE breath-hold imaging was also performed to assist in interpreting the axial data.

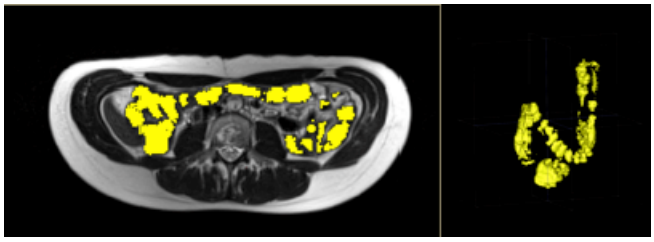

**Figure 1. Left: Slice quantification of bowel gas in the transverse colon**. Voxels with signal intensity of 2x background noise or less are included. **Right:** 3D rendering of a segmented large

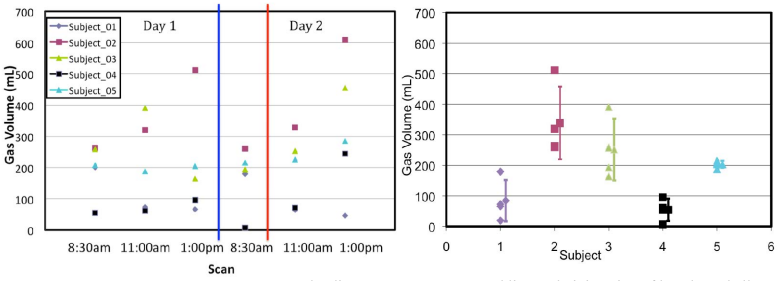


**Figure 2. Left: Large Bowel Gas Volume.** Blue line: Day 1 vs. Day 2; Red line: Administration of lactulose challenge Subjects were scanned 4 times prior to lactulose administration (Day 1 @ 8:30, 11:00, and 13:00; Day 2@ 8:30).. In general an increase in bowel gas volume is observed as the day progresses. **Right: Large Bowel Gas Volume Variability**. Subjects were scanned 4 times prior to lactulose administration.

**Analysis** Image segmentation was performed with a MatLab based segmentation software, The Tissue Segmenter, which was created in house (Silavi) and allowed the user to manually segment volumes of interest (VOI), calculating the area, volume and signal intensity for the VOI (Figure 1). The total volume of gas in the large bowel was calculated after determining which image voxels were in the large bowel and contain gas but not other bowel constituents. Basic statistical analyses (paired t-tests) were completed on the gas volume measurements acquired at the same time (eg. 8:30 am) between Day 1 and Day 2. A correlation analysis between the GI questionnaire responses for each scan and the segmented large bowel volumes for each scan was completed.

**Results** In self reported normal controls, it was observed that after a standardized diet, gas volume in the large intestine increased throughout the morning (except for subject 1) (Figure 2: Left). It was also observed that there is a large variation in what is considered to be the normal range for gas volume changes throughout the early part of the day (Figure 2: Right). There were no significant differences between gas volume measurements at the same time of day between Day 1 and Day 2 for these subjects and there was no correlation between the subjective GI questionnaire results and the gas volumes.

**Discussion** Interestingly, this study observed an increase in gas volume in healthy controls, who were given a standardized diet, over the early portion of the day. The lack of significant differences between the gas volume measurements at the same time of day between Day 1 and Day 2 suggests that our MR acquisition technique and segmentation methods are stable, given that the gas volume is consistent in healthy subjects between Day 1 and Day 2. Future work will include further validation of the technique using a phantom that mimics the large intestine, increasing the number of healthy controls to confirm the increase in gas volume observed through the early portion of the day and an extension of the simple 2 day, 6 scan protocol that is currently being used. Finally, this MRI method of quantifying large intestine gas volume could have significant application in inflammatory bowel disease.

**References** [1] Singh et al., *Ann R Coll Surg Engl.* 2010; 92(3):182-8.