The effect of of meal calorie content on water secretion and absorption in the GI tract using MRI.

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Introduction

Small bowel water content is potentially an important parameter in studying normal gastrointestinal physiology, and also clinical conditions such as Irritable Bowel Syndrome and Celiac disease. After eating there is a complex interaction between the stimulation of gastric, intestinal and pancreatico-biliary secretions (increasing intestinal contents) and absorption of nutrients and sodium (decreasing intestinal contents). We have recently developed a method of assessing small bowel water content[1]. Recent studies[2] using this technique have shown that bran increased small bowel water content and suggested that a fatty, liquid, preload caused an increase in small bowel water content and contraction of the gall bladder. The aim of the study was to test our hypothesis that ingesting glucose after a period of fasting will stimulate water absorption from the small bowel compared with a non-nutrient iso-osmolar mannitol solution. We further hypothesised that adding a fatty preload would enhance small intestinal water content by stimulating pancreatico-biliary secretions.

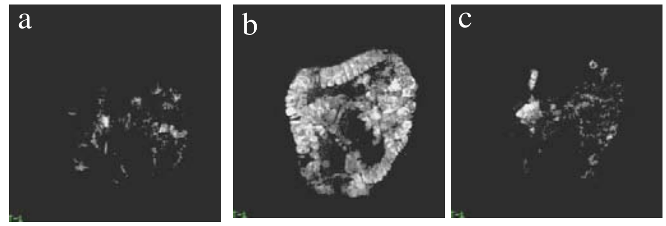

Figure 1: MIPs of the bowel for a single volunteer 70 minutes after ingestion of (a) glucose (b) mannitol and (c) glucose with preload.

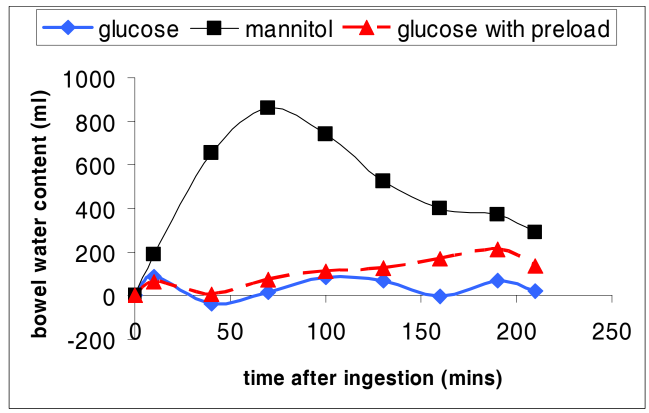

Figure 2: Graph to show the change in estimated bowel water content compared to baseline for a single volunteer for each model meal

Method

Volunteer Selection: Five healthy volunteers, with no history of gastrointestinal disease, formed the study group. The study was approved by the local ethics committee and all volunteers gave written informed consent.

Meal Descriptions: Three different model meals were used in the study: 350ml still water with 17.5g of either mannitol powder or glucose powder (with and without a Calogen preload). The preload converted fasting motility patterns to the fed state. The mannitol and glucose solutions had the same osmolarity.

Study Protocol: Volunteers were asked to attend at 7:30am having fasted overnight and having abstained from alcohol for 24 hours, and from caffeine and exercise for 18 hours. Volunteers were scanned before consumption of the test meals to provide a baseline set of measurements for the study day. Volunteers consumed the 350ml drink over 10 minutes. Images were acquired on a 3T Philips Achieva MRI Scanner using a SENSE Torso coil. Single shot coronal TSE (RARE) (TE=400ms, FOV=400mm, reconstructed matrix=512x512) images were acquired during two breatholds. This was repeated at approximately 30 minute intervals over 4 hours.

	% of gastric volume at 40 minutes	Interquartile range	AUC of bowel water content (ml.min)	Interquartile range
Glucose	42	30-51	7580	-2830-11600
Mannitol	20	18-48	72200	58900-111000
Glucose with preload	58	46-59	22600	14800-24500

Table 1: Median % of ingested volume remaining in the stomach after 40 minutes and median AUC for the volume of water in the bowel

Analysis: Gastric half emptying times and % of ingested volume remaining at 40 minutes were measured from gastric volume measurements made from the TSE images. Volumes of fluid in the bowel were calculated at each time point by integrating the volume of all image pixels above a threshold, after exclusion of signal from regions other than bowel; the area under the curve (AUC) for the period of the whole experiment was calculated for each volunteer.

Results

Figure 1 shows a maximum intensity projection (MIP) image for a single volunteer of the bowel at the 70 minute time point for each meal. A higher bowel volume can clearly be seen after consumption of the mannitol meal. Figure 2 shows the excess bowel water content after consumption of each meal for a single volunteer. Table 1 summarises the results for all subjects and shows that the nutrient meals were emptied from the stomach more slowly as expected and that mannitol caused a massive increase in bowel water content compared to glucose. The preload also caused an increase in bowel water content compared to glucose. Resting bowel water content was low and did not change significantly after consumption of glucose.

Conclusion

As expected, glucose stimulated rapid absorption of fluid while mannitol was associated with net water secretion. This reflects the high permeability of the jejunum to sodium, causing sodium and water to move down the electrochemical gradient between plasma and the gut lumen, whereas by contrast, glucose solutions are rapidly absorbed as expected. A fat containing preload increased bowel water content compared to glucose, probably due to stimulation of pancreatic and biliary secretions. The gastric emptying of glucose was slower than the non-nutrient mannitol and further delayed by a fat containing preload as expected. MRI allows a detailed description of the complex interactions between secretion and absorption in the upper GI tract. This is important baseline data that will be used in the interpretation of the results of experiments on more complex meals.

References

1. CL Hoad et al, abstract submitted to this meeting.
2. L Marciani, *et al.* Proc. Int. Soc. Mag. Reson. Med. 14, 2006, p840.
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