MRI assessment of the water distribution in the ascending colon in health and a model of diarrhoeal disease

E. Placidi[1], C. L. Hoad[1], L. Marciani[2], E. F. Cox[1], S. Pritchard[1], C. Costigan[3], R. C. Spiller[2], and P. A. Gowland[1]

[1]SPMMRC, School of Physics and Astronomy, University of Nottingham, Nottingham, United Kingdom, [2]Nottingham Digestive Diseases Centre Biomedical Research Unit, University of Nottingham, Nottingham, United Kingdom, [3]Brain and Body Centre, University of Nottingham, Nottingham, United Kingdom

Introduction:

We currently have a rudimentary understanding of the physical factors which influence access of drugs and bioactives, such as bile and proteases, to their site of action at the colonic mucosa. This is because of a lack of non-invasive measurement techniques. Our aim was to develop MRI methods to study colonic function in undisturbed physiologically relevant conditions, avoiding the bowel preparation including enemas often used in colonic MRI to improve anatomical detail. The aim of this work was to image the contents of the colon at high resolution in order to assess the water distribution in the colon (using T_2 values) and to determine quantitatively the relationship between water content in the small intestine and ascending colon (AC). This was a proof of principle study, using MRI assessment of the AC and small bowel to monitor the effect of mannitol, a laxative known to stimulate small intestinal secretion which can be used as a model for a range of diarrhoeal diseases.

Methods:

This study was carried out with ethics committee approval. Five healthy volunteers were imaged on a 1.5 T Philips Achieva scanner using a SENSE 4-element abdominal body coil on two different occasions having fasted overnight: one day 100 min after drinking 350 ml of tap water and another day 100 min after consuming the same drink plus 5% of mannitol (conditions randomized). The time delay was determined from previously acquired data[1] which showed the majority of subjects with water in the AC at 100 min after the mannitol drink. A range of MRI sequences was used to image the AC. These included: a bTFE sequence with TE=1.5 ms, TR=3 ms, which acquired 3 slices with a slice thickness of 7 mm and slice gap of 5 mm to investigate a small region of the AC. A high resolution T_2-weighted TSE sequence with TE=100 ms, TR=600 ms, (acquired resolution of 0.5 mm x 0.5 mm) was also acquired with 12 slices, of 4 mm thickness and 4.1 mm slice gap. Total bowel and AC water content was measured using a MRCP sequence and a previously described analysis method[2]. T_2 in the AC was also quantified in a single slice from a T_2-prep bTFE sequence[3], with TE=1.3 ms and TR=2.6 ms.

Results:

Very little fluid was seen at 100 min after the water drink in the small bowel or AC. In three subjects there was a large amount of fluid in the AC, clearly visible on the MRCP images at 100 min after the mannitol drink, and for the remaining 2 subjects the MRCP images at 100 min clearly showed the fluid in the small bowel had not reached the AC and was still in the distal small bowel, and so the imaging was repeated 140 min after ingestion of the mannitol drink. The bTFE images (Figure 1a) showed a very heterogeneous signal in the colon following water ingestion whilst a more homogeneous, brighter signal was evident following the mannitol drink in the colon, which was markedly distended. The high resolution T_2-w images showed low signal in the AC following water, but bright homogeneous signal in the AC following the mannitol (Figure 1b). Table 1 summarizes the T_2 of the colonic contents in the two conditions, measured using the T_2- prep bTFE (Figure 1c: the colonic contents were generally brighter in the centre and darker at the edge after the mannitol, and so the T_2s were measured in the two regions separately). Figure 2 shows the water content for the whole bowel and AC, quantified from the MRCP sequence (MIPs of segmented data shown in Figure 1d).

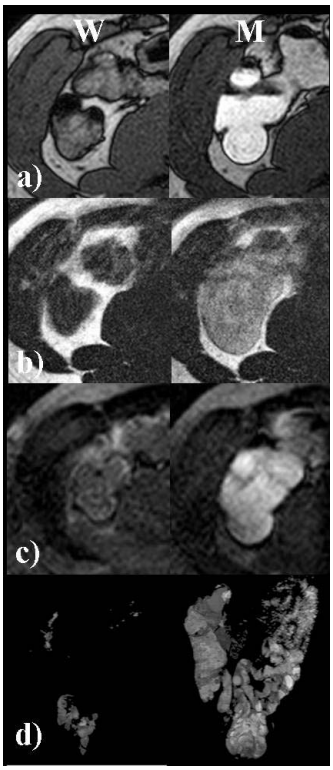

Figure 1 Typical transverse images of the colon after the water only (W) and the mannitol (M) drinks for the same volunteer. a) bTFE; b) T_2-w HiRes; c) T_2-prep bTFE; d) MIP of MRCP (coronal).

Discussion and Conclusions:

We investigated a number of sequences for studying the contents of the small bowel and used these to assess changes in water content in the AC in terms of water volume and T_2 in response to mannitol. Most of the sequences showed signal changes resulting from the expected increase in colonic water following ingestion of mannitol. The T_2s of the bright regions on the T_2-prep bTFE images after the mannitol drink were considerably higher than those measured in the colon after just water, whereas the T_2s of the darker regions were more similar to those measured in the colon after the water only drink. This suggests that the large inflow of fluid from the small bowel is not rapidly mixed with less fluid chyme present in the colon. The different imaging techniques used showed that increases in water content in the bowel from the mannitol drink resulted in more homogeneous signal intensity in the colon compared to the undisturbed state. We used the mannitol drink in this study as it stimulates fluid secretion in the small bowel thereby mimicking other causes of acute diarrhoea. This allowed us to probe the signal characteristics of these imaging sequences in response to changes in colonic water content as well as quantifying both T_2 and water content in the AC and will help us optimise sequence parameters for imaging diarrhoeal disease. Improving understanding of the spatial and physical properties of the colonic contents will help in designing better drug delivery vehicles. It may also be useful for studying the effect of different foods (eg high fibre) on colonic contents, and for understanding some of the resistance to eating high fibre diets.

	T2 (ms)		
Volunteer Number	Water	Water+Mannitol	
		brighter	darker
1	45.0	311.0	128.0
2	41.3	216.0	116.0
3	49.9	493.0	-
4	88.1	524.1	-
5	67.0	191.1	40.0

Table 1 T_2 values calculated from the T_2-prep bTFE sequences: for the mannitol drink, brighter and darker regions were seen in the colon on the images and T_2s were calculated for both regions.

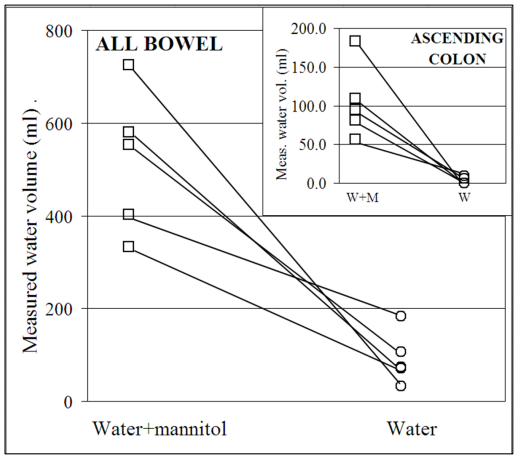

Figure 2 Total and AC water content measured using a MRCP sequence showing the larger quantity of fluid after the mannitol drink compared to after the water only drink.

References:

1 Cox et al. 15th ISMRM (2007) p.893;
2 Hoad et al Phys. Med. Biol. **52** (2007) p.6909–6922;
3 Hoad et al Proc.14th ISMRM (2006) p.2506.