Gastric emptying, transit times and visualisation of alginate beads in the gastro-intestinal tract

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Introduction

The study of small bowel diseases using MRI is well established[1], but the study of normal small bowel physiology using serial MRI has not yet been realised. Small bowel disease is visualised by distending the small bowel lumen with water by using preparations that prevent absorption. This approach is not acceptable when studying normal physiology as water is naturally secreted and absorbed in the small bowel. MRI is potentially a powerful technique for studying gastrointestinal physiology, as it is relatively non invasive, and because it can measure many different, related functions within a single experiment. The aim of this study was to determine the effect of bead strength on the gastrointestinal response to a model meal containing solid beads, using MRI to visualise and quantify the beads in the stomach and small bowel.

Materials and Methods

Volunteer Selection: Seven healthy volunteers, with no history of gastro-intestinal disease, formed the study group. The study was approved by the Local Ethics Committee and all volunteers gave written informed consent.

Meal Descriptions: Two different bead types were used as model 'solids' in the study; solid centre alginate beads (strongly gelled) and liquid centre alginate beads (weakly gelled). These were 2-4 millimetres in diameter and made by dropping 200 ml of 1.5% w/w solution of Manugel DMB (ISP, Köln, Germany) into 0.37% CaCl soln for different lengths of time[2]. The meals were randomised in a double blind fashion. In addition to the beads, the volunteers consumed 500 ml of distilled water to help the volunteer swallow the beads without chewing and to provide contrast to the beads in vivo.

Study Protocol: Volunteers were asked to attend at 7:45am having fasted overnight and having abstained from alcohol for 24 hours, and caffeine and strenuous exercise for 18 hours. Volunteers were scanned before consumption of the test meals to provide a baseline set of measurements for the study day. A fat pre-load meal of 50 ml Calogen (SHS International Ltd, Liverpool, UK) was given to the volunteers 15 mins before the main bead meal to turn the GI tract into a fed state. Volunteers consumed the bead meal over 15 mins. Images were acquired on a 3.0 T Philips Intera Achieva MRI scanner. Coronal RARE (TE=400ms) images of the small bowel and transverse HASTE (TE=59) images of the stomach were acquired during 2 breathholds for each image type. These acquisitions were repeated at approximately 30 minute intervals over 4 hours. Five minutes before the 4 hour scan 200 ml of water was given to the volunteer to aid visualization of any beads that were left in the stomach. A satiety questionnaire[3] was completed by the volunteer before each imaging period.

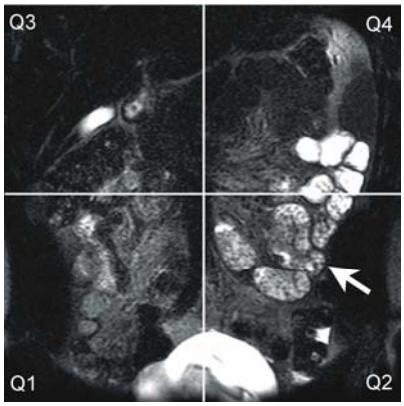

Figure 1. Typical coronal RARE image of the small bowel. Arrow shows visible beads in small bowel. Q1-4 represent the four quadrants used in the analysis.

Analysis: Gastric half emptying times were measured from gastric volume measurements made from the HASTE images. Bead visualisation was scored by one operator using the RARE images in the whole image and four quadrants of the intestine (0 – no beads visible, 1 – few beads visible, 2 – many beads visible). (See figure 1) The quadrants were defined in a coronal image, with the centre being at the inter-vertebral disc between L2 and L3 of the spine. These scores were integrated over the whole time period to give a visualisation score (max 16). The time for the meal to initially reach the cecum from the mouth, was also measured from the coronal images. The areas under the satiety curves (AUC) were calculated.

Results

The median gastric half emptying times for the meals containing weak and strong gelling beads were 39 mins and 45 mins respectively (inter-quartile range: weak 34-50 mins, strong 39-65 mins). This was despite the weaker beads having a larger initial volume as they retained more water in the gelling process. The median time to cecum for both sets of beads was 120 mins. No beads were observed in the stomach after the water refill. The AUC for the fullness scores to 240 min was statistically higher for the weak compared to strong beads ($p=0.043$, N=7 Wilcoxon Signed Ranks Test). The median visualisation scores for the whole intestine were 15 and 14 for the weak and strong beads respectively with no statistical differences between them, however the integrated visualisation scores in the different quadrants were statistically different for both the weak and strong beads ($p = 0.002$ (weak), $p=0.003$ (strong), N=7 Friedman Test) with quadrants 3 and 4 having lower scores than 1 and 2.

Conclusions

This experiment showed that it is possible to visualise small beads in the stomach and small bowel to track the progress of a meal through the GI tract. Gastric emptying was longer for the stronger beads despite the smaller volume for this meal. These results are in good agreement with previous studies[4]. The AUC fullness data suggest that gastric volume dominated the fullness rating for this model meal. Beads were visualised in all areas of the small bowel, however they were seen more in the lower quadrants of the small bowel; which is likely to contain mainly the ileum and distal jejunum. Both bead strengths were observed to reach the cecum intact and no differences in transit time from mouth to the cecum were observed between the bead types, suggesting that, in contrast to the stomach, the intra-intestinal forces could not differentiate the bead types. The errors for this measurement were large due to the measurement interval of 30 mins and difficulty in determining if beads had arrived at the cecum if no fluid was also present.

References

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