The effect of high fat or high carbohydrate meals on the gastrointestinal tract: a MRI study

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Background

Overconsumption of calories on high fat diets suggests fat is less satiating than carbohydrate. Previous MRI studies have shown layering of fat in the stomach reduced the rate of delivery of nutrients to the duodenum but led to faster early gastric emptying of the non-fatty fraction of the meal [1,2]. We hypothesised that a layering high fat (HF) meal would empty its non-fatty fraction faster than a high carbohydrate (HC) meal of the same nutrient content, leading to reduced satiety in the early phase of gastric emptying. However, it was uncertain how this would alter the later satiety response as the impact of the fat on pancreatic secretions and small bowel water content (SBWC) was unknown.

Aim

To compare the effects of a HF meal and an equicaloric HC meal on satiety, gastric volumes, SBWC and gallbladder (GB) contraction (as a marker of CCK release) using MRI.

Method

18 healthy subjects (9M/9F, 20.7 ± 0.1 years old, BMI 22.9 ± 0.5 kg/m^2) were fed a 525 kcal rice pudding meal with 22 g double cream added to make a high fat (HF) meal (calories: 48% carb, 45% fat, 7% protein) or with 50 g Maxijoule (glucose polymer) added to make a high carbohydrate (HC) meal (calories: 87% carb, 6% fat, 7% protein). A transverse balanced turbo field echo (BTFE) sequence was acquired for gastric and GB volumes (24 slices, in plane resolution 1.56 x 1.56 mm^2, slice thickness 10 mm) and a coronal magnetic resonance cholangiopancreatography (MRCP) sequence was acquired in order to measure the SBWC (24 slices, in plane resolution 0.78 x 0.78 mm^2, slice thickness 7 mm) [3]. Serial MRI scans and assessments of fullness, hunger and appetite based on visual analogue score (VAS) were performed at 45-minute intervals for 270 mins post prandially and the area under the curve (AUC) calculated for these parameters. The rice pudding meal was consumed immediately after the T = -45 mins fasting measurements.

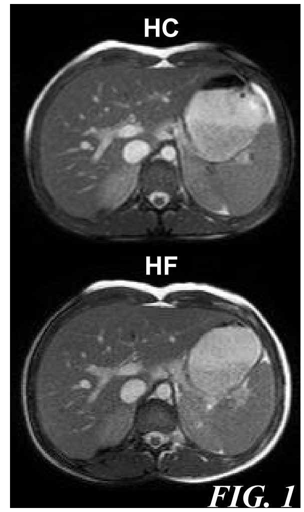

FIG. 1

Results

FIG. 1 shows sedimentation of the stomach contents following both meals at T = 0 min.

FIG. 2 shows change over time for satiety, gastric emptying, SBWC and GB volume. Compared to the HF meal, the HC meal gave increased sense of fullness (AUC, $p < 0.003$), hunger was reduced (AUC, $p < 0.0003$) and appetite was reduced (AUC, $p < 0.002$). Gastric emptying from 0 - 90 mins was slower for the HC meal than the HF meal, (volume at T = 90 min, $p < 0.0003$). SBWC initially fell following both meals, but after 135 mins, was significantly higher for the HF meal (ANOVA, $p < 0.03$). The % GB contraction was not different between the meals at T = 180 mins ($p < 0.6$).

Discussion

Layering of the fat in the fundus accelerates gastric empting [2] and this is likely to explain the reduced satiating effect of the HF compared to the HC meal in the early postprandial phase (0 - 90 mins); in the early phase of gastric emptying satiety appears to depend mainly on gastric distension. The later increase in postprandial small bowel water after the HF meal might be attributed to layering of the fat in the fundus [2] leading to delayed gastric empting of fat which then stimulates pancreatic secretions, and also the need to emulsify the fat. We will test this in future studies with meals designed to empty at similar rates. The increase in SBWC does not however appear to significantly increase satiety, but any effect may be suppressed by the fact that the subjects are already quite hungry at T = 180 mins when the SBWC peaks. Future experiments will be designed to investigate this.

Conclusion

We have used MRI to investigate the interaction between meal fat content, satiety response and GI function.

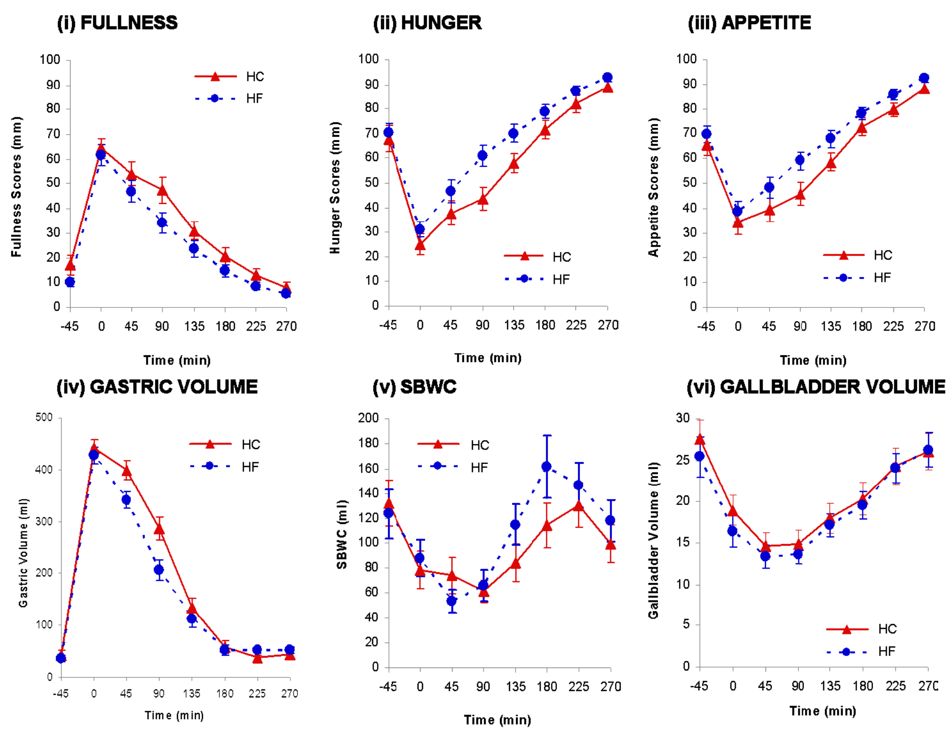

FIG. 2 (mean ± SEM)

References

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