Dynamic EPI Monitoring of Intragastric Secretion, Mixing and Emptying of Viscous Meals in Man: Influence on Satiety.

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Introduction

The role of gastric secretions in intragastric processing of food is poorly understood both in normal subjects and in patients with atrophic gastritis and non-ulcer dyspepsia. It is important to be able to study food dilution and mixing without the use of invasive techniques such as nasogastric intubation and radioactive tracers and snap-shot MRI provides a unique tool for the dynamic monitoring of gastric function [1]. We have recently developed a method for monitoring intragastric dilution of model meals using EPI [2]. The aim of this study was to use this method to assess dilution, mixing and emptying of viscous meals in normal subjects by EPI and to relate these parameters to satiety, a key factor in human eating behaviour.

Subjects and Methods

12 fasted healthy volunteers attended on 4 sessions and ingested 500 ml of one of 4 polysaccharide locust bean gum meals chosen in random order between low (0.06 Pas) and high (29.5 Pas) viscosity (η), either non nutrient or nutrient (1350 kJ of lipids and carbohydrates). Single-shot MBEST EPI images were acquired at 0.5 T, 3.5x2.5x10mm^3 resolution and 40 ms effective T_E. T_2^{-1} vs dilution calibration data sets were measured for each meal *in vitro* at 37° C using spin-echo EPI (8 echo times from 60 to 700 ms repeated once, T_R=10 s). After ingestion transverse rapid multislice volume and T_2 sets were acquired on breath hold every 12 min until the stomach appeared empty. Volunteers sat upright in between scanning. Satiety feelings were assessed on self-report scales every 12 min. The half gastric emptying time T(50%) was calculated. Gastric secretion volumes were calculated using the calibration data sets and T_2 maps of the stomach contents were also produced. The satiety scores were plotted against time and the area under the curve (AUC) calculated and averaged for each meal. Data are reported as mean±SEM. Statistical analysis was performed using Friedman and Wilcoxon tests for paired comparisons versus the low viscosity control meal. This protocol was approved by the local ethics committee and volunteers gave informed written consent prior to experiments.

Results

T_2^{-1} against meal dilution calibration curves were obtained *in vitro* for all meals and were used to calculate meal dilution from the EPI *in vivo* T_2 measurements. Remaining meal and secretion volumes were calculated at each time point using the meal T_2 and the *in vitro* calibration curves. Fig. 1 shows the variation with time of gastric secretion volume for the nutrient meals. Gastric emptying was mostly influenced by nutrients with T(50%) delayed from 32±7 to 76±6 min between low η non nutrient and high η nutrient meals, $p< 0.001$. Satiety was instead mostly influenced by meal viscosity, with an increase in the AUC for the sense of fullness from 420±54 to 567±37 between low η non nutrient and high η nutrient meals, $p< 0.02$. A linear relationship between gastric volumes and volunteer's sense of satiety was found (Fig. 2). The dilution maps (Fig. 3) showed the heterogeneous process of viscous meals dilution and mixing, with secretions slowly ingressing from the meal boundaries towards the core. Low viscosity meals were homogeneously diluted.

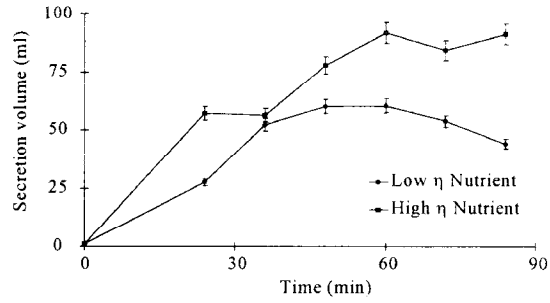

Figure 1: Time variation of the gastric secretion volume for the nutrient meals, calculated using the gastric volumes, the meal T_2 measurement *in vivo* and the T_2 *in vitro* calibration data.

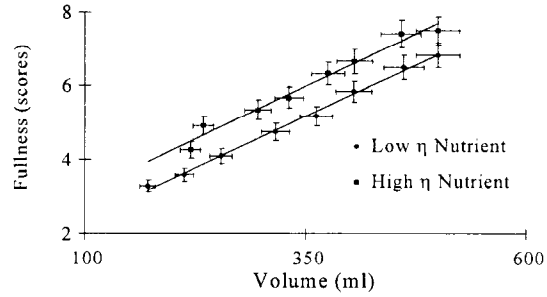

Figure 2: Dependence of satiety on gastric volumes for the low and high viscosity nutrient meals (data grouped according to time of measurement).

Discussion

This study showed the flexibility of ultra-fast MRI in monitoring the key physical parameters of gastric processing of food such as gastric secretions, mixing, and emptying. These studies are noninvasive and were generally well tolerated, hence it is possible to simultaneously measure satiety. Gastric emptying was more influenced by meal nutrient content than viscosity, possibly due to the duodenal response to the presence of nutrients, in spite of a 500 fold increase in viscosity. Satiety was instead influenced mostly by meal viscosity and was linearly related to gastric volumes. This may be explained both with a cephalic/vagal response to viscosity and with the response of stretch receptors in the antral walls. This observations suggest that by manipulating meal viscosity it would be possible to increase fullness and prolong digestion times, hence reducing the intestinal absorption rate of nutrients to help obesity treatment.

Conclusion

This study demonstrates the use of EPI in the dynamic monitoring of gastric function, noninvasively and with high spatial resolution. This method could also be applied to evaluate conditions like atrophic gastritis and non-ulcer dyspepsia. Work in progress is extending the EPI investigation to intragastric processing of model solid food.

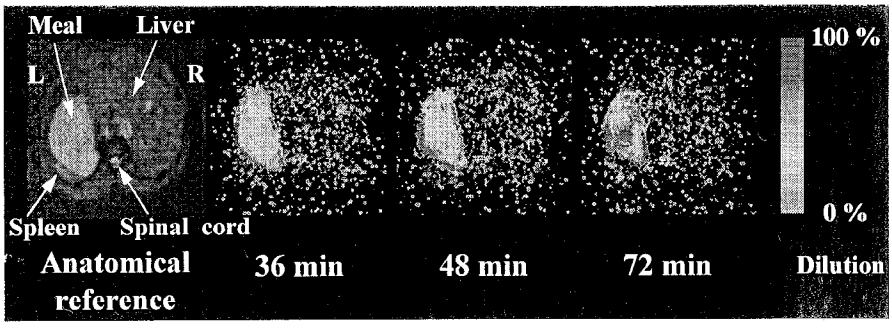

Figure 3 Dilution maps at different digestion times obtained using T_2 mapping the spin echo data sets acquired in vivo and *in vitro* meal dilution calibration curves.

References

1. Sica GT, *Radiology* 207:9-10, 1998.
2. Marciani L et al, *JMR* 135:82-86, 1998.

Acknowledgments

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