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Influence of a subsequent meal on the oro-cecal transit time of a solid test meal

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Abstract

Background Oro-cecal transit time (OCTT) is determined for clinical diagnostics of intestinal complaints and research purposes. Ingestion of a subsequent meal during the test period shortens the OCTT of a liquid test meal (glucose solution), as previously reported. This study was conducted to determine whether the same phenomenon occurs after ingestion of a solid test meal.

Materials and methods The OCTT of a pancake was measured with the lactose-[^{13}C]-ureide breath test on two occasions in 28 volunteers. All the volunteers took the same subsequent meal once at 4 h and at 6 h after ingestion of the pancake.

Results In 16 of the 56 tests no increase in breath-$^{13}CO_2$ was observed. No statistically significant difference was found between the OCTTs of the test meal after ingestion of the subsequent meal at 4 h or 6 h (367; 311–405 min and 290; 370–405 min, median quartiles, respectively) ($P = 0{\cdot}14$, $n = 18$). Only a subgroup ($n = 4$) with a short OCTT in the test with the 4-h subsequent meal (278; 259–296 min) tended to have a longer OCTT in the test with the 6-h subsequent meal (390; 379–401 min; $P = 0{\cdot}059$).

Conclusion The effect of the ingestion of a subsequent meal on the transit time of a test meal is shown to be dependent on the physical form and/or caloric content of the test meal.
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Introduction

Small intestinal transit time and oro-cecal transit time (OCTT) is measured to assist diagnosis of gastrointestinal complaints, to assess the effects of treatment and for research purposes. The duration of the measurements of OCTT is more than 4 h which makes inclusion of a subsequent meal necessary. As applied protocols vary with respect to the inclusion of such a subsequent meal, we examined in a previous study [1] whether the inclusion of a subsequent meal influences the outcome of the measurement. In the previous study, the OCTT of a liquid test meal (glucose solution) was compared between four groups of healthy volunteers who consumed the subsequent meal at various time points, which showed that consumption of a subsequent meal during the test period can influence the rate of transit of a previously ingested liquid meal through the gut. In our studies OCTT was measured by the lactose-[^{13}C]-ureide breath test. Lactose-[^{13}C]-ureide resists enzymatic degradation in the small intestine but is cleaved by colonic bacteria [2]. As a result of the bacterial fermentation of labelled urea, $^{13}CO_2$ is released and can be measured in the breath [3,4]. Increased $^{13}CO_2$ in breath indicates the arrival of the front of the test meal in the cecum. Scintigraphic studies have reported that dietary residues and liquid-phase marker accumulate in the ileum and are transferred into the cecum in bolus movements across the ileocolonic junction [5–9]. As the entrance of food into the stomach results in increased motility of the gastrointestinal tract [10] we concluded that consumption of the subsequent meal causes the transfer of the marker into the cecum and the observed rise in $^{13}CO_2$.

This study was conducted to investigate whether the effect we observed in our previous study, with a liquid test meal, also occurs after ingestion of a solid test meal.

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Methods

Subjects

Twenty-eight (20 female and eight male) apparently healthy volunteers (mean age 22 years, range 19–30 years; Body Mass Index 22·5 kg m^{-2}, range 16·7–30·7 kg m^{-2}) who had no history of gastrointestinal disorders participated in the study. They had not taken any antibiotics or laxatives during the 3 months before the test. Verbal informed consent was obtained from all subjects. The protocol of the study was approved by the Ethics Committee of the University Medical Center, Groningen.

Experimental protocol

The study was conducted in a crossover manner with each subject taking part in two tests at least 1 week apart. In the first test the subsequent meal was ingested at 4 h and in the second test at 6 h after intake of the solid test meal. Both tests were conducted under the same conditions, with exception of the time of intake of the subsequent meal.

At 20:00 h, the evening before the tests, 1·0 g of unlabelled lactose-ureide in 150 mL of water was taken by all subjects. This was to induce the enzyme activity of colonic bacteria that is necessary to cleave the sugar-ureide bond [11].

After an overnight fast (> 10 h) the subjects ingested a pancake that contained 500 mg of lactose-[^{13}C]ureide as marker of the transit time. The lactose-[^{13}C]-ureide was added before baking to 150 g of the pancake-batter which was made from 400 g of pancake mix, Koopmans Pannenkoekmix (Koopmans Meel BV, Leeuwarden, the Netherlands), 200 g of eggs and 750 g of milk. The pancake was cooked in 5 g of oil and served with 5 g of sugar (330 kcal in total). The volunteers did not consume any food during the whole test period except for the subsequent meal. Water and tea without milk and sugar were allowed to be taken after 2 h from intake of the solid test meal onwards. During the test period the volunteers remained seated and refrained from smoking.

Breath was sampled by breathing through a straw into 10-mL exetainers. Two breath samples were collected before ingestion of the test meal. During the 8 h after intake of the test meal breath samples were collected every 15 min.

The subsequent meal consisted of two bread rolls with ham or cheese and one glass of milk (415 kcal: 52% carbohydrates, 22% protein, 27% fat) and was consumed within 15 min.

Analytical methods

The ^{13}C abundance in breath CO_2 was determined by gas isotope ratio mass spectrometry (IRMS) Breath MAT (Finnigan MAT, Bremen, Germany) measuring the $^{13}C/^{12}C$ ratio as $\delta^{13}C$ vs. Pee Dee Belemnite Limestone ($\delta^{13}C_{PDB}$) in permil.

The OCTT was defined as the time elapsed between ingestion of the test meal and a sustained (> 3 time points) rise of > 2·0 δ^{13}C above baseline.

Statistics

Data are expressed as median with quartiles. Differences between the OCTT results were assessed using the Wilcoxon Signed Ranks test. For differences between the results of the test with the solid and the liquid test meal the Mann–Whitney *U*-test was used. The analyses were performed with the statistical program SPSS 11·0 for WINDOWS software (SPSS Inc., Chicago, IL); $P < 0{\cdot}05$ was considered to be significant.

Results

Effect of subsequent meal on OCTT

In 16 of the 56 tests no clear increase in breath-$^{13}CO_2$ was measured during the study period. Six volunteers did not respond with an increase in $^{13}CO_2$ in both tests and four did not respond in only one test (one volunteer in the test with the 4 h and three volunteers in the test with the 6-h subsequent meal). The median (quartiles) OCTT of the test with the 4-h subsequent meal was 368 min (296, 409) and that of the test with the 6-h subsequent meal 390 min (371, 400). The results were not significantly different ($P = 0{\cdot}14$). Figure 1 depicts the individual values of the two tests. Only four volunteers showed an increase of $^{13}CO_2$ in breath within 1 h after intake of the 4-h subsequent meal (median OCTT 278 min; quartiles: 259, 296). These four volunteers had a longer OCTT in the test with the 6-h subsequent meal (390; 379, 401 min) which, however, was not statistically different ($P = 0{\cdot}059$).

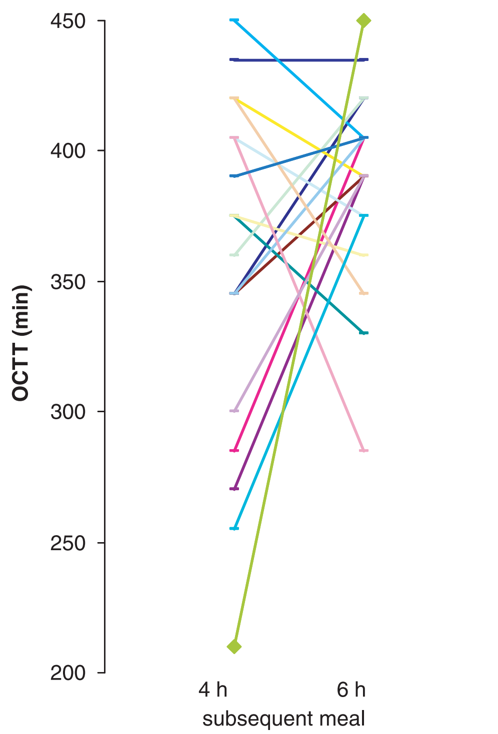

Figure 1 Individual oro-cecal transit time (OCTT) of a solid test meal with the subsequent meal taken after 4 h and 6 h.

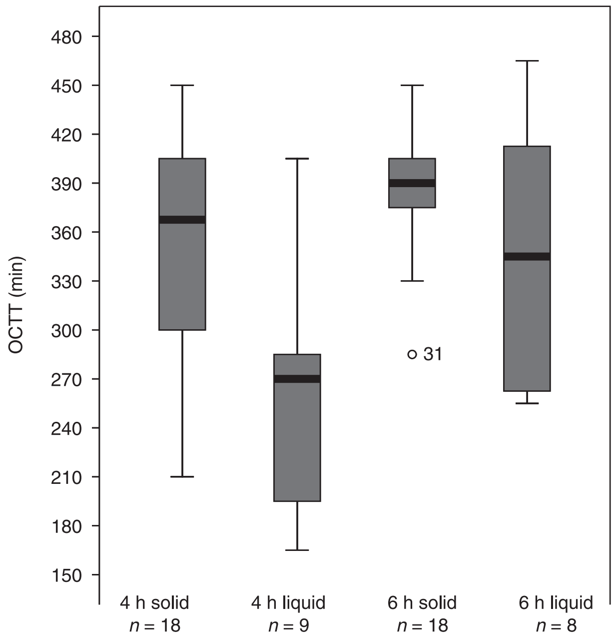

Figure 2 Oro-cecal transit time (OCTT) of a solid and liquid test meal (data from previous study) with the subsequent meal taken after 4 h and 6 h.

Comparison of results: solid and liquid test meal

Comparison of the current data with our previous study with the liquid test meal is shown in Fig. 2.

In the test with the 4-h subsequent meal the OCTT of the liquid test meal was significantly faster than that of the solid test meal ($P = 0{\cdot}02$) and in the test with the 6-h subsequent meal the OCTT of both test meals did not differ ($P = 0{\cdot}20$).

In the test with the 6-h subsequent meal five of the eight volunteers had an OCTT shorter than 360 min after the liquid test meal and four of the 18 after the solid test meal.

Discussion

Previously we reported that intake of a subsequent meal influences the OCTT of a liquid test meal and concluded that when dietary residues or labelled indigestible markers have reached the ileum, increased bowel motility owing to the ingestion of a subsequent meal can cause their transfer to the cecum.

In this study we found that the OCTT of a solid test meal (pancake) is not affected by ingestion of a subsequent meal at 4 h. Only four of the 18 volunteers (22%) showed an increase in $^{13}CO_2$ within 1 h after intake of the 4-h subsequent meal, which indicates meal-related bolus transfer of the OCTT marker, as shown in the previous study. Lack of an increase of breath-$^{13}CO_2$ indicates that in most subjects no lactose-^{13}C-ureide was present in the ileum that could have been transferred to the cecum at the time point of the ingestion of the subsequent meal. This suggests that the intestinal transit of the solid meal took longer than that of the liquid meal. Based on the characteristics of our test meals, differences in transit time could be possible because both meals differed in the physical form as well as in macronutrient (8 g, 10 g and 12 g more fat, protein and carbohydrates, respectively) and caloric content (330 and 100 kcal, respectively). Solid meals as compared with liquid ones are emptied slower from the stomach, as are meals with higher energy density [10]. Also, increased nutrient loads retard small intestinal transit time [12–14], although data are conflicting with regards to fat [15].

Studies comparing the OCTT of solid and liquid meals or meals with a different caloric content are scarce. Bennink *et al.* [5] reported no difference in OCTT between a solid (scrambled eggs with bread: 230 kcal) and liquid test meal (water) measured with scintigraphy (median OCTT 285 min). The study is comparable to ours with respect to the inclusion of a 4-h subsequent meal and the caloric difference of both meals. However, the transit of the liquid and solid meal was measured simultaneously with different radioactive tracers, which makes comparison with the results of our study difficult.

When the subsequent meal is consumed at a late time point (6 h), the chance of ‘spontaneous’, thus meal-independent, bolus transfers will be increased. When comparing the effect of the 6-h subsequent meal on the OCTT of a solid and liquid test meal no statistically significant difference in median OCTT was found. This, however, could be owing to the large variability of the $^{13}CO_2$ response after the liquid test meal. Interestingly, five of the eight volunteers (62%) had an increase of breath-$^{13}CO_2$ before the ingestion of the 6-h subsequent meal after the liquid test meal as compared with four of 18 volunteers (22%) after the solid test meal, which supports the assumption of a faster OCTT of the liquid meal. We further observed that the subgroup of volunteers that had a rise in breath-$^{13}CO_2$ within 1 h after the intake of the 4-h subsequent meal tended to have a slower OCTT in the test with the 6-h subsequent meal. This suggests that people with a rapid gastrointestinal transit might be susceptible to the intake of a subsequent meal; however, this needs to be confirmed in a larger study population.

In conclusion, the ingestion of a subsequent meal does not affect the transit time of a solid meal. This is in contrast to the result of our previous study in which the transit of a liquid test meal was affected by the ingestion of a subsequent meal. The discrepancy of our findings could be explained by the longer gastrointestinal transit time of the solid test meal owing to its physical form or caloric content. People with an intrinsically short OCTT, however, can be expected to respond to a subsequent meal even after a solid test meal.

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